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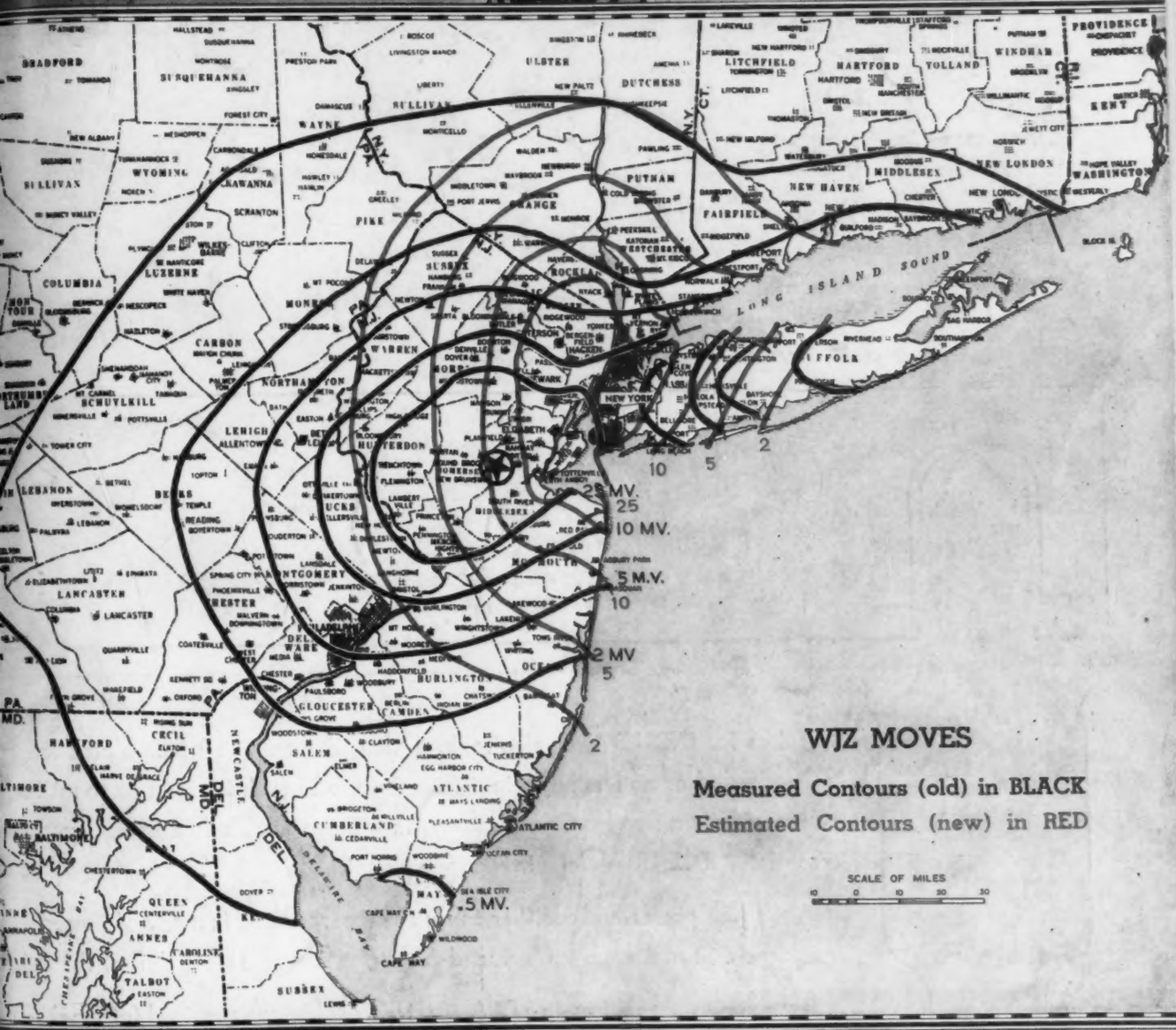
Electronics



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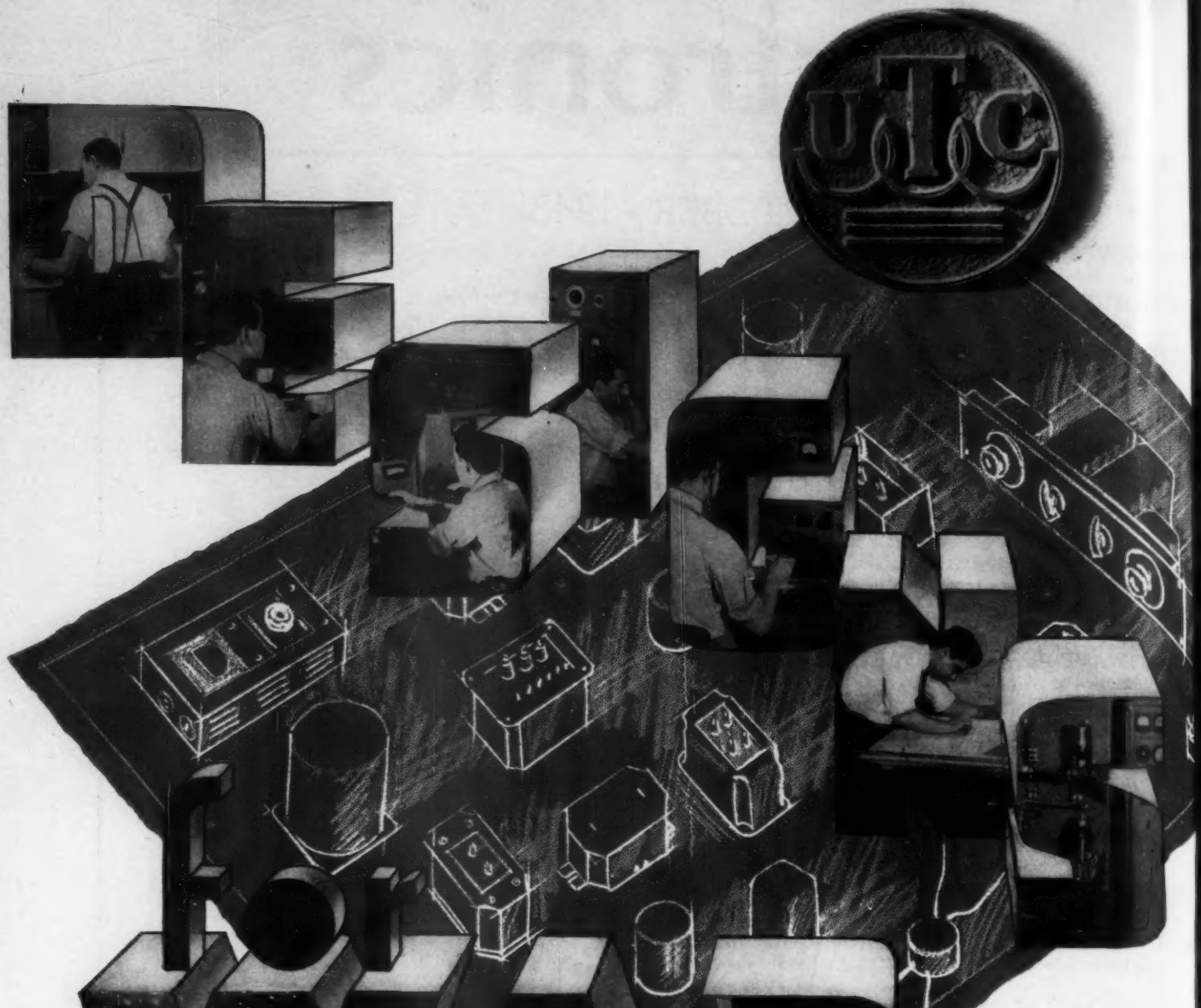

The bulk of UTC production today is on special units designed to specific customers' requirements. Over 5,000 new war designs were developed this past year. These designs ran from open type units to hermetically sealed items capable of many cycles of high and low temperature and extreme submersion tests. They included units from 1/3 ounce in weight to 10,000 lbs. in weight and from infinitesimal voltages to 250,000 volts. It is impossible to describe all these thousands of special designs as they become available. Our staff of application engineers will be more than pleased to discuss your problem as related to special components.

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WASHINGTON FEEDBACK

☛ Government officials whose particular business it is to chart the immediate and long-distance trend of production in the electronics industry are now frankly assuming greater and greater output. The plateau on which it was feared the industry might hang on a dead center has turned out to be a mirage. No plateau is in sight. To the contrary, Ray C. Ellis, Director of the Radio and (Censored) Division of WPB, pointedly declares that schedules must be stepped up between now and the end of December to put the industry on a four billion dollar annual production basis, with a 30 to 40 percent increase in 1944 in the military requirements that the industry must meet.

The actual output of military electronic equipment for July 1943 was $234,000,000. In order to reach the four billion dollar annual figure, the monthly dollar volume of production must jump to approximately $333,000,000 per month or nearly $100,000,000 per month increase over the July total. Much of the increase will be for large, expensive equipment as well as replacement parts.

With this outlook, there is apparently increased determination on the part of Government not to permit the production problems of the industry to interfere with the full realization of the projected program. Mr. Ellis expresses it this way: "Output must be maintained and increased despite difficulties in the field of critical components, experienced labor and other problems facing us."

Several steps in the direction of easing the path of the manufacturer have been taken in addition to the very prominent placement accorded to the industry in the new "Critical List" of the War Manpower Commission. Major General William H. Harrison, new chief of the Signal Corps Procurement and Distribution Service, has held conferences with prime contractors in the sections where the manufacturers' plants are located, resulting in better understanding and increased cooperation between the Signal Corps and the manufacturers. In fact, much credit for the recent rise in production of military communications equipment is given to General Harrison, who took over his present post July 1, 1943.

Another step is the selection of the vacuum tube industry by WPB's Office of Labor Production for a test survey of manpower problems. Whatever procedure is arrived at in this industry probably will be extended to the rest of the electronics field. A certified schedule from each plant of the work being done, the expected expansion, statistics on labor turnover, absenteeism and the number of hours that the employees are on the job will be requested.

CMP Complaints—The WPB order amending the CMP Class "B" products list to place the manufacture of special military communications equipment in the Class "A" designation beginning January 1, 1944 is being reviewed by WPB with the intention of making changes if it seems advisable. One of the complaints of the industry was that the new Class "A" listing would necessitate a more complicated clerical setup and additional help at a time when this is almost an impossibility.

Instrument Ratings—Members of the Industrial Instrument Industry Advisory Committee, meeting with WPB Radio officials recently, declared that reduction in priority ratings for key components would be detrimental to the industrial instrument industry. The contention was advanced by members of the committee that while the industry uses a small percentage of the overall production of key components, industrial instruments are vital to the functioning of war plants and therefore should have higher ratings. Stressed also was the wide variety of products covered in its scope, including thermostats, control valves and gauge glasses.

Radio Resistors—Prospective expansion of radio resistor facilities will provide sufficient capacity to meet requirements of the armed services during the remainder of 1943 and the first half of 1944, according to WPB. The Radio Division continues to recommend that manufacturers accept orders only to the extent of their ability to produce. Under priorities Regulation 1, manufacturers may refuse orders which they cannot deliver because of commitments on equal or higher rated orders. If this practice is followed, purchasers will be forced to sources which are in a position to make the delivery.

FCC Relaxes Rules—Acting on the report of FCC's Committee on Critical Radio Materials, the Commission has relaxed the April 27, 1942 "freeze order" covering new broadcast construction or improved facilities to allow licensing of new local stations of 100–250 watts power, where prescribed conditions can be met. The report of the committee, comprised of Commissioners T. A. M. Craven and C. J. Durr, was the result of a year's study to determine whether additional stations could be licensed or powers increased without hindering the war effort. The committee found that there are 84 applications filed now with FCC for new stations involving power of 250 watts or less and 13 applications for increase in power from 100 to 250 watts. No encouragement is given to applicants seeking increased power or other improved facilities outside the local bracket because of production bottlenecks in the higher-wattage equipment and tubes. Furthermore, tube replacements for FM transmitters are unusually tight because of heavy military requirements for copper anode tubes.

Based also on findings of the Craven-Durr committee, the Commission has announced that under certain conditions it would authorize "judicious" use of idle equipment to increase the power of relay broadcast stations—when existing power is insufficient, to improve the service and even to construct new relay broadcast stations for definite purposes. Applicants must show that all required materials may be obtained without priority assistance for either construction or maintenance.—G.T.M.

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CROSS TALK

▶BD . . . On October 1, ELECTRONICS takes another big step forward. On that date, Mr. Dudley, for 7 years a member of its editorial staff and for the past 2½ years its managing editor, takes up residence in Chicago as ELECTRONICS' Western Editor. The territory in which Mr. Dudley will represent his paper editorially is a vast proving ground for electronic principles, and it rates a full-time editor of his publishing experience and professional standing. Mr. Dudley will be located at the McGraw-Hill office at 520 North Michigan Boulevard, telephone Whitehall 7900; and he will be available for consultation about prospective editorial manuscripts, about technical problems in the fields of electronic control and communication or on any other matter in which an engineer-editor can be helpful.

▶FM vs AM . . . A point that continually crops up in arguments pro and con on this hot subject is that of the respective service ranges of FM on a line-of-sight basis and AM on a God-knows-what basis. It is argued that since FM is on the high frequencies, it is good only to the horizon and this horizon is not very far away from the transmitting antenna.

The useful range of a broadcast station on any frequency is the distance over which it can be heard clearly. This is the only range that can be sold an advertiser. On the standard broadcast band this is the day-time distance over which the station can be heard above ambient noise. This distance is not very great. At night, however, the same station can be heard, and can create interference, over much greater distances. This is not good service although plenty of people in the country have to listen to it. It is a fact that the night-time service of many local stations is worse than the day-time listening because of interference created by stations at much greater distance.

FM, on the other hand, can be heard no further at night than in day and, as yet, there is no interference whatever. The difference in range between a medium-power FM job on 45 Mc and a high-power AM job on 1000 kc is not very great. A high-power FM transmitter near Boston is regularly and clearly heard in Long Island day or night when nothing whatever can be heard from standard AM broadcast stations in the same region.

By the way—FM listeners in New York City are getting a tremendous kick out of the NBC Symphony at 5 o'clock on Sundays. Here is broadcasting at its best. The joy of hearing these programs via NBC's FM transmitter is matched in intensity only by the disappointment that CBS still has not seen fit to put the New York Philharmonic-Symphony orchestra on its New York FM station.

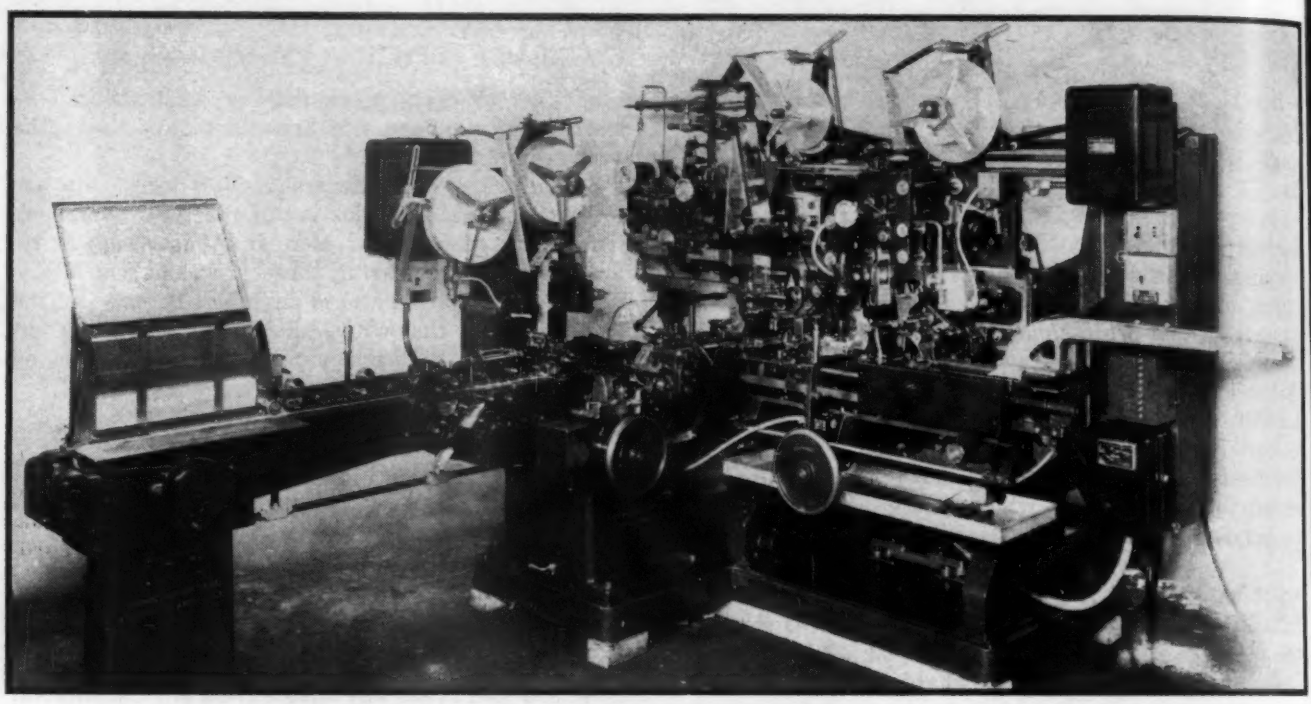
▶RESEARCH . . . On the subject of research, we quote from an item on this page in November 1935. According to Dr. C. E. K. Mees of Eastman Kodak, research is a gamble. It cannot be conducted according to the rules of efficiency engineering. He states that "research must be lavish of ideas, money and time. The best advice that I can give is don't quit easily, don't trust anybody's judgment but your own; especially don't take any advice from any commercial person or financial expert, and, finally, if you really don't know what to do, match for it." Furthermore Dr. Mees said, "The best person to decide what research work shall be done is the man who is doing the research. The next best is the head of the department.

"After that you leave the field of best persons and meet increasingly worse groups. The first of these is the research director, who is probably wrong more than half the time. Then comes a committee, which is wrong most of the time. Finally there is the committee of company vice presidents, which is wrong all the time."

▶BAZOOKA . . . Job for the War Department: the new rocket gun which punctures tanks like nobody's business is familiarly called the bazooka. So is a gadget which matches a coaxial line to a doublet antenna. Imagine the opportunity for disaster on the field of battle when somebody puts in a hurry call for a tank buster and gets a coaxial line matcher!

Phototube Control of PACKAGING MACHINES

Unit designs have largely supplanted over-all designs formerly used as labels on wrappers, bags and other merchandise containers. Electronic controls insure proper register of cuts between successive designs when continuous printed webs are used



Package Machinery Company unit used by American Chicle for the automatic handling of Dentyne chewing-gum. Strips of the product are cut into individual sticks at the left, wrapped in printed paper at the center, wrapped in foil and printed paper in groups of six at the right

THERE HAS BEEN a noticeable trend, in packaging and bag-making, toward more extensive use of a printed "unit" design on the wrapper or bag. Unit design tends to supplant the so-called "over-all" design commonly used in the past.

When a unit design is used, it is much less expensive to print on a continuous web of paper than on individual pre-cut sheets. Also, the handling difficulties associated with certain stocks, such as cellophane, make web printing almost essential.

When a printed web is run into a processing machine, such as a bag-tuber or a packaging device, the printed design must be kept in register with the cutter. The slightest error in the relation between the feed-roll travel per machine resolution and the spacing of the printing on the web will result in cutting through the printed design. Even though the error is only 0.1 percent initially, after a few hundred sheets have been run cuts will often occur in the middle of the printed sheet rather than at the end.

A packaging or bag-tubing machine equipped for handling a printed web must incorporate some provision for varying the timing of the draw roll (the roll that draws the paper into the machine) and the rolls that cut off the web. There must also be some means for insuring that the register of the printed matter is synchronized with the operation of the cutting knife. This can be done efficiently by using a phototube to scan the printing and to compare its relative position with that of the cutter.

Register Mark Problems

Since the whole system depends on the phototube response to light impinging upon the printing on the web, the selection and spacing of printed register marks and the method by which the phototube views

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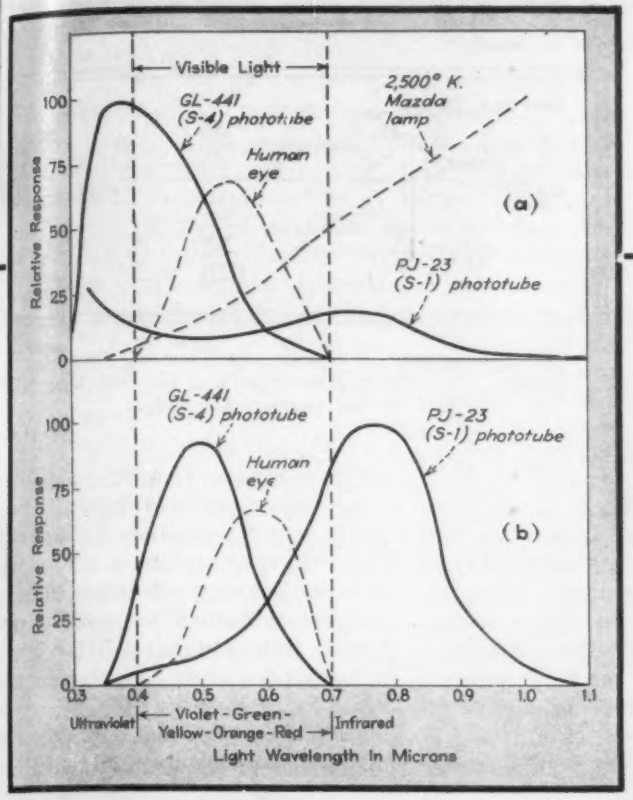


FIG. 1—Response characteristics of two typical phototubes, (a) showing sensitivity to different colors and (b) showing relative response to these colors when they are illuminated by an incandescent lamp

these marks are all very important.

To obtain the required amount of light-change at the phototube, we are concerned with the total amount of light striking the phototube and also with the percent change of that light. Obviously, a large percentage change is desirable since it minimizes the effects of small changes in light source intensity due to lamp aging, dirty lenses, or to a change in color or transparency of the material being registered. Figure 1a shows the absolute sensitivity of two common types of phototubes to lights of different colors, while Figure 1b shows the relative response to the colors

Unit merchandise designs, printed in web form, showing register marks at margins. Reflected light is used for control

Unit designs on cellophane. Transmitted light is used for control, the register marks appearing between individual labels

▼

when illuminated by an incandescent lamp, the light generally employed for this work.

The total amount of light striking the phototube depends on the intensity of the light beam, transparency or reflection of the packaging material, the inks used, and the size of aperture before the phototube. To obtain the greatest accuracy, the aperture before the phototube must be narrow in the direction of web motion. Thus, the large effective light change between a highly polished metallic foil surface and a dark ink, or between a directly transmitted beam (such as used with cellophane or with a slit cut in the paper) will result in greater accuracy than would be expected with the same equipment operating on the contrast between a dark line and brown kraft paper.

Light Reflection Technique

To register from a printed line on opaque paper, it is necessary to operate by light reflected to the phototube from the surface of the paper. For this purpose, we may use a scanning head and light source such as that shown in Fig. 2, or a more elaborate head which includes an amplifier tube. Typical scanning head optical systems are shown in Fig. 3.

When registering on cellophane, either reflected or transmitted light may be used, depending on which

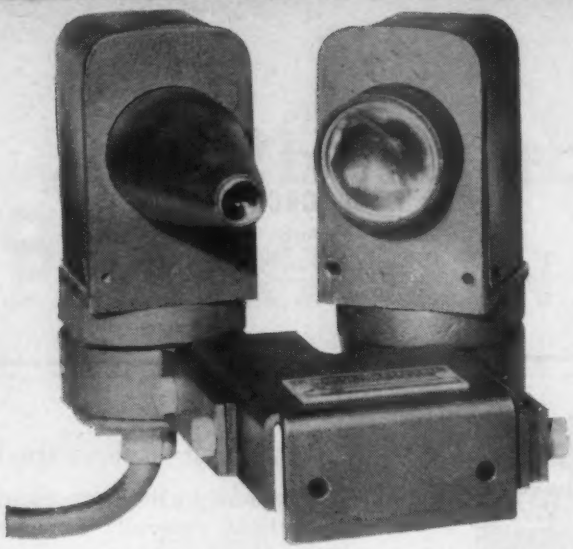


FIG. 2—Typical scanning-head, used where light transmitted from the source is reflected from register marks into the phototube

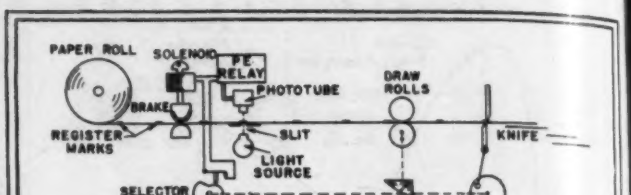


FIG. 5—Schematic of typical intermittent-fed packaging machine. Transmitted light rather than reflected light is used in this instance for control

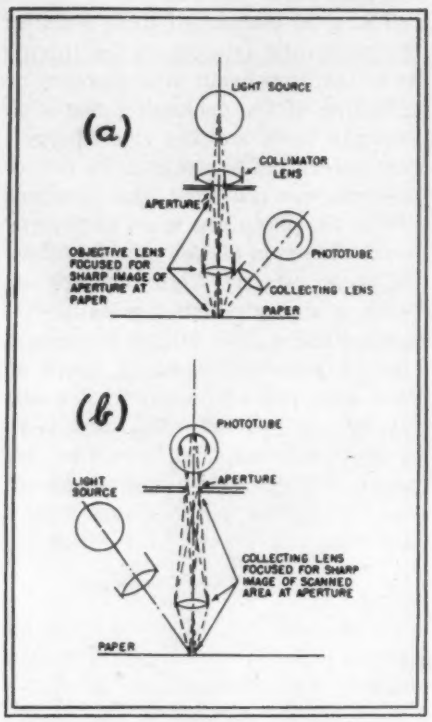


FIG. 3—Elemental lens systems for scanning a paper surface (a) where a sharply defined spot is desired and (b) where viewing of a definite area is desired

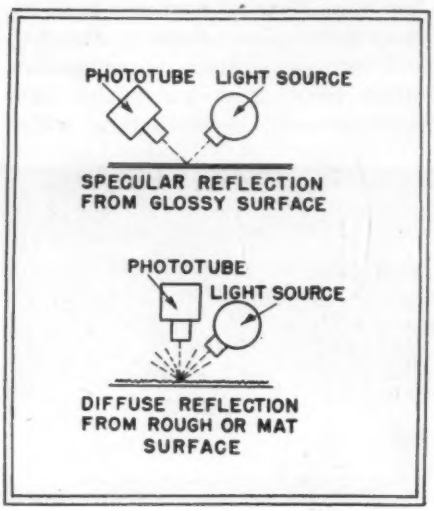


FIG. 4—Arrangement of light source and phototube for specular reflection and for diffuse reflection, the method chosen being dependent upon the character of paper and register marks as explained in text

will produce the greater light change. It is difficult to lay down hard and fast rules as to when each should be used. Light reflected from the surface of a material is of two kinds, "specular" (or mirror) reflection and "diffuse" reflection from a somewhat rough surface, wherein the light is scattered equally in all directions, as shown in Fig. 4.

Specular reflection from a mirror or prism can redirect most of the light beam into the phototube, whereas diffuse reflection, such as from a sheet of white paper, may permit only a small percent of the light to reach the phototube. When specular reflection is used, the phototube must be located quite accurately, otherwise the sharply directional reflected beam may miss it completely. A diffused reflected beam will be effective over a much wider area. Shiny surfaces such as polished foil and waxed or lacquered paper have a high degree of specular reflection. Since most of the light is reflected from the surface of the lacquer and does not penetrate to the paper surface, it is sometimes not practical to register by specular reflection from a printed line which is covered by a coat of lacquer or wax. The smaller the angle between beam and paper (the more nearly parallel the beam is to the paper surface), the greater is the amount of specular reflection.

Color differences are invariably seen by diffuse reflection. If there is considerable specular reflection present, it minimizes the percent change of light due to color contrast. Hence, there may be conditions where a white mark printed as a matte pigment surface may reflect less light to the phototube than the spectral reflection from a highly polished black background. Such a problem is solved by moving the light source or phototube so that the specular ray misses the phototube and only the diffuse white light is received.

Light Transmission Data

When working with cellophane and using light transmitted through rather than reflected from the material, much depends on the type of ink used for the printed register marks. A pigment ink will simply block off the light so that for a given thickness of ink the change in response is fairly independent of color. However, when a dye is used, the lack of an opaque ingredient will generally permit more light to pass and require a more serious consideration of the color used.

A practical register mark is usually made about twice as wide as the accuracy desired. For instance, for an accuracy of plus or minus 1/64 inch, or a total tolerance of $\frac{2}{64}$ inch, a mark $\frac{1}{16}$-inch wide is suggested. The edges of the mark must be well printed and sharply defined. The length of the mark perpendicular to the motion depends largely upon the amount of side motion expected in the web. Normally, the phototube or scanning head views a section about $\frac{1}{4}$-inch wide, so the total width of the mark must be sufficient to prevent the mark from shifting from the scanned point. For most applications, a mark $\frac{1}{2}$ inch long is suitable.

The position of register marks

must be continuously compared with the packaging or wrapping machine cycle. The method of comparison used varies with each type of machine and drive. It may employ a simple shutter which permits the phototube to look at the marks only at definite times. Quite often cam-driven contacts are in use in place of a shutter to "arm" the phototube equipment at certain critical intervals. Where greatest speed and accuracy are desired, a disk having slits accurately spaced and viewed by a second phototube is frequently used.

Packaging Machine Action

Correction must be applied after a misregister has been detected. The method of doing this depends on the design of the machine and the ingenuity of the machine designer. On intermittent-fed machines, the stroke may be lengthened or shortened slightly. If the feed rolls are small, it may be possible to use a compensating roll such as is customary in the printing press industry. However, for the majority of applications it has been found most desirable to use a differential gear between the draw rolls and the cutter. Which part of the machine should be driven directly and which through the differential is determined principally by the comparative power required for the two elements and the effect of the shock on the gearing at the time the cut is made.

Standard Phototube Relays

For slow-operating machines, particularly those having an intermittently-fed sheet, and where the demands of accuracy are not too great, the use of standard or general purpose phototube relays, without modification, is often practical.

Where the cycle of the machine is determined by the time required for the packaging operation rather than by the time required to properly feed the paper, the feed may be moved forward until the register spot intercepts the light beam, at which time the phototube relay will cause the paper drive to be stopped or a brake to be applied to the web as shown in Fig. 5. Then, after the cut has been made, an interlocking arrangement will permit the sheet to be again brought forward and the process repeated.

Greater accuracy may be obtained with a given phototube relay by using a form of variable-speed drive, wherein the major part of the sheet motion is at comparatively high speed but is slowed down near the end of travel. In addition to the time required for the operation of the phototube relay, sufficient time must be added for the mechanical operation of the corrective device used.

A somewhat different type of intermittent-speed machine moves the web each time slightly more (or slightly less) than required. The cumulative error then adds up in a few impressions to the point where the register mark operates the phototube relay and produces a one-way correction which brings the mark back to the beginning point. This saves considerable wear on the correcting mechanism, as it does not have to operate for every impression.

A step towards higher-speed operation is to apply the same principles

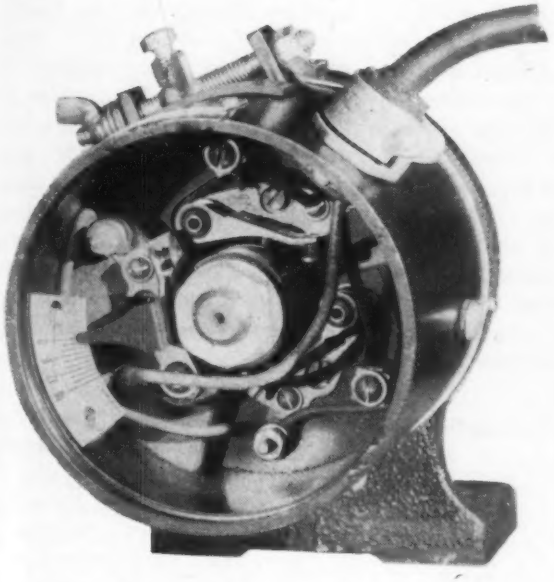


FIG. 6—Rotary selector switch used in connection with phototube register control

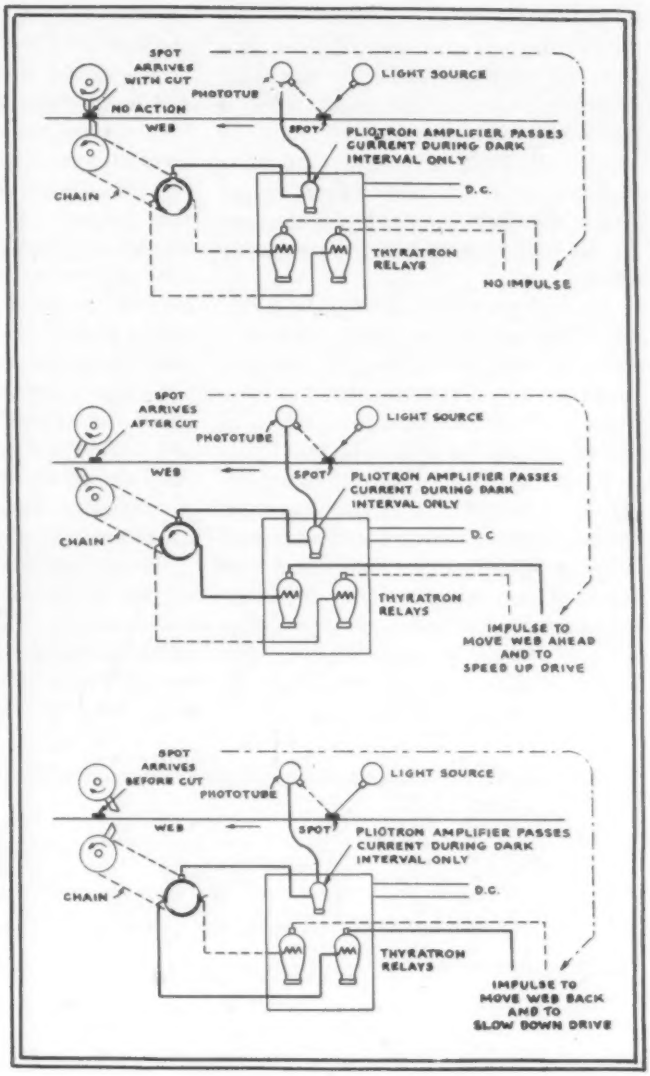


FIG. 7—Schematic diagram of two-way control system which corrects for either fast or slow paper web movement

to continuously-fed stock, always feeding the stock slightly faster or slower than required until the accumulated error in the position of the register mark, checked against machine-driven contacts, indicates that a correction is needed. Contacts which indicate the position of the cutter or other processing elements are usually cam-driven. They are referred to as rotary selector switches.

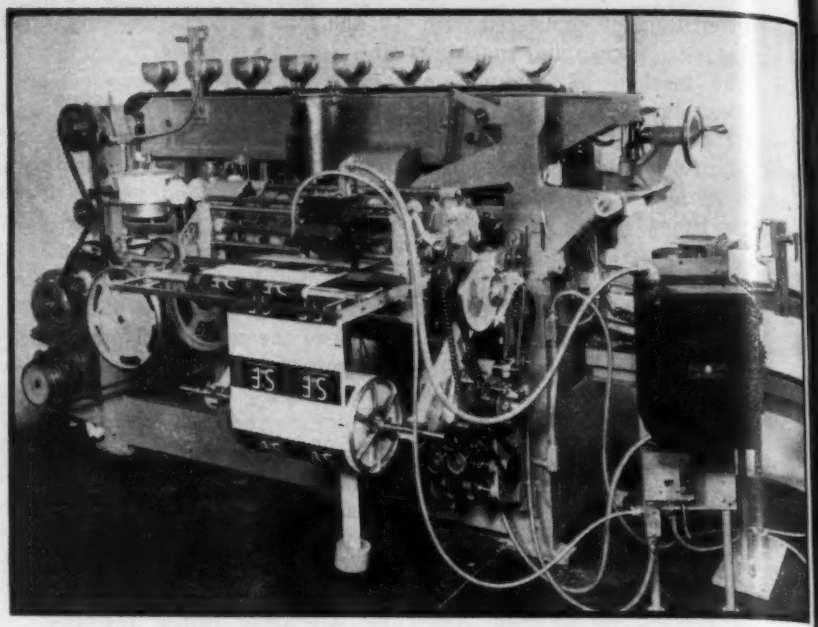
One and Two-Way Corrections

The one-way type of register control is capable of producing a correction in only one direction. Its operation is based on the principle of overfeeding or underfeeding, as described above.

Since controls made expressly for such work usually employ an advanced type of scanning head (wherein the amplifier tube is enclosed with the phototube) and provisions are made for a selector switch they operate with a higher degree of accuracy and respond to a smaller color contrast than standard relays.

Capacity coupling is used between phototube and amplifier. Such a system will respond readily to the rapid changes in light that occur when a register mark passes, but may be made relatively insensitive to slow changes such as those caused by aging of the light source or by changes in the background color of the paper used.

The extremely small operating signal obtained from a slight color contrast as seen through a very narrow aperture requires that the amplifier tube be placed as close as possible to the phototube so that the signal will not be lost through excessive capacity or inductance in the connecting leads. Although local conditions will have a great influence upon the speed of operation and the accuracy permissible, apparatus of this type is not generally recommended for paper speeds of greater than 50 feet per minute or an accuracy of greater than plus or minus $\frac{1}{32}$-inch.



Another typical packaging machine. The printed wrapper web, with register marks, is seen near the center. The electronic register control panel is visible at the right

The next logical step after one-way register control, is to add a second contact to a rotary selector switch (such as the one shown in Fig. 6) and an additional control circuit, so that the correction may be made in both directions. When using this method, the draw-rolls are set to pull the paper as near to the correct length as possible. Then, any tendency for the paper to go ahead of or lag behind the correct register point is detected by the phototube. The operation of the selector switch indicates the proper direction of correction. An adjustable time-delay circuit is provided so that the correction can be preset to give the best results. A schematic diagram of such an arrangement is shown in Fig. 7.

As long as the correction is made in one direction only, the register mark creeps a fixed distance from the correct position, causing the control to operate and bring it back. However, with two-way register control, we are faced with the problem of the error or tolerance of register in each direction from normal which may be permitted before the apparatus is actuated.

Required Register-Mark Tolerances

The tolerance over which the register mark may move without causing control operation is called the "dead zone", and is shown in Fig. 8. This dead zone must be at least equal to the width of the register mark plus the increment of correction to be made, otherwise each time a correction is made it will throw the register mark to the opposite side of the dead zone and a reverse correction will be made. This will cause undersirable hunting. If the construction of the machine is such that the complete correction cannot be made before the next spot arrives, it will be necessary to increase the size of the dead zone to allow for the follow-up action so that hunting will not start.

It is absolutely necessary that register marks be equally spaced along the web well within the tolerance of register; otherwise, alternate marks might touch opposite sides of the dead zone and start a hunting cycle of their own. It is necessary also that the tension of the paper feed be such that slip of the draw roll will not permit radical changes in the length of cut for which the control cannot compensate.

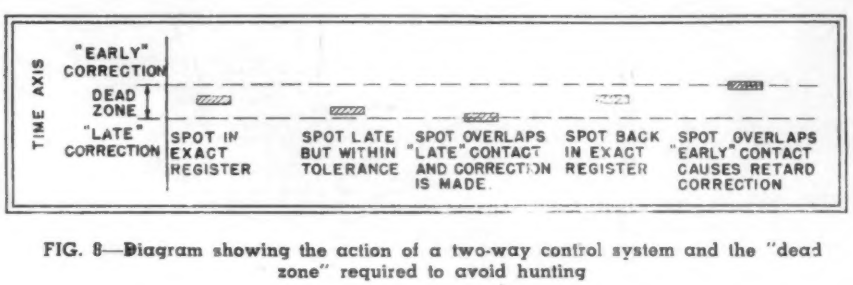

TIME AXIS
"EARLY" CORRECTION
DEAD ZONE
"LATE" CORRECTION
SPOT IN EXACT REGISTER
SPOT LATE BUT WITHIN TOLERANCE
SPOT OVERLAPS "LATE" CONTACT AND CORRECTION IS MADE
SPOT BACK IN EXACT REGISTER
SPOT OVERLAPS "EARLY" CONTACT CAUSES RETARD CORRECTION

FIG. 8—Diagram showing the action of a two-way control system and the "dead zone" required to avoid hunting

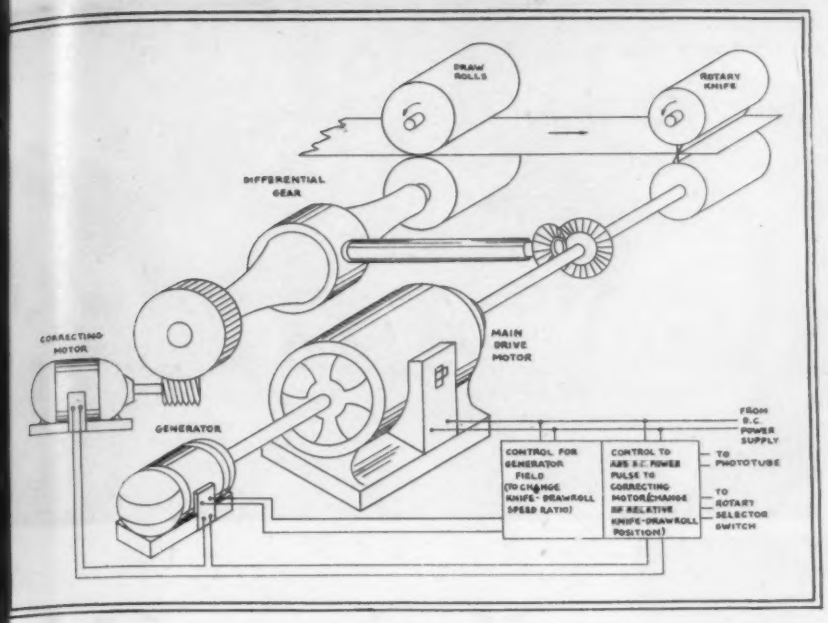

DRAW ROLLS
ROTARY KNIFE
DIFFERENTIAL GEAR
CORRECTING MOTOR
MAIN DRIVE MOTOR
GENERATOR
FROM D.C. POWER SUPPLY
TO PHOTOTUBE
TO ROTARY SELECTOR SWITCH
CONTROL FOR GENERATOR FIELD (TO CHANGE KNIFE-DRAWROLL SPEED RATIO)
CONTROL TO ADD D.C. POWER PULSE TO CORRECTING MOTOR (CHANGE IN RELATIVE KNIFE-DRAWROLL POSITION)

FIG. 9—System incorporating both speed and space correction for extreme accuracy in maintaining register at a high-speed rotary knife of a packaging machine

Since it is impossible for the scanning head to view the register mark at the ideal point, i.e., that at which the cut takes place, we must compromise and view the spot at some position as close as possible to this point. If it is necessary to place the scanning head more than a few register-mark lengths away from the cut, any error (due to shrinkage, etc.,) occurring between register marks will accumulate. This usually is not a serious problem provided the scanning head can be kept within four or five bag lengths from the cut-off point.

As mentioned previously, at higher paper speeds, the differential type of correction is almost universally used. The correction made by this type of equipment should consist of a correction of space or phase angle between the draw roll and the cutter. It is almost impossible to attempt to change just the relative speed of draw roll and cutter without setting up a disastrous hunting cycle.

When using two-way register control, the accuracy and speed permissible depend upon local conditions. It is generally not desirable to operate such equipment at greater web speed than 200 feet per minute. An accuracy of plus or minus 1/64 inch can be obtained where means are provided to keep a constant tension on the feed roll. Signal lights operated from the forward and reverse contacts will give a good indication of whether or not the tension is correct.

Control Employing Speed Change

Another possible refinement is control of the relative speeds of the draw roll and cutter, in addition to their space relations. This may be accomplished mechanically by controlling the tension on the feed roll as each space correction is made. Great care must be taken, however, that the speed change is not sufficiently great to overbalance the space change, otherwise hunting will take place. One form of combined speed and space change is obtained with a single correcting motor, by the use of a contactor and rheostat panel in conjunction with a two-way register control panel. Such a system is illustrated in Fig. 9.

The draw rolls are set to pull the paper through the machine at a speed approximately 1 percent fast. The correcting motor is then geared to a differential as shown in Fig. 10, so that when running at full speed, the differential will cause the draw roll to turn 1 percent slow. Thus, with the correcting motor stopped, we have a speed 1 percent fast and, at full speed, 1 percent slow. Therefore, when the correcting motor is running at approximately 50 percent speed, the draw rolls will be pulling the paper at approximately the correct speed. Also, since the correcting motor is bucking the main motor, its load is extremely light and it is very responsive to changes in armature voltage. By means of an auxiliary control panel, we may then momentarily retard or advance the speed of the correcting motor to obtain a space change and may increase or decrease its average speed to obtain a corresponding effective speed relation change.

In order that the correcting motor may at all times turn at some convenient percentage of the speed of the main motor even though the machine may run fast or slow, the correcting motor is driven by a generator that is geared to the main motor drive. The correcting-motor field is constant and produces maximum torque, but the generator field is fed from a potentiometer rheostat on the control panel. This rheostat is then rotated with each corrective pulse. From the power line, a small direct voltage is fed to the motor armature in a direction which produces the required momentary space-change operation. This system has the added advantage that the average speed of the web is always kept nearly correct. The increment of space correction may thereby be reduced to a much smaller value than that used in the two-way space register control alone.

Equipment using this type of register control has been known to operate at 400 or 500 feet per minute with an accuracy of register of plus or minus 1/64-inch. It must be

(*Continued on page* 180)

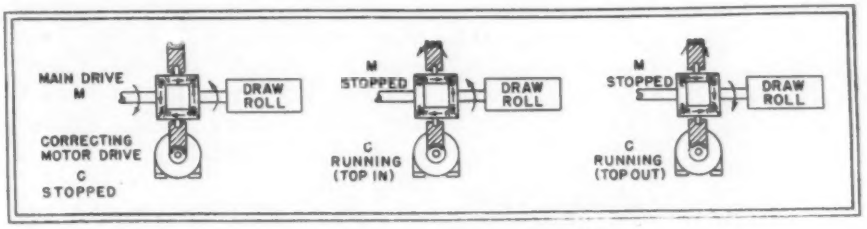
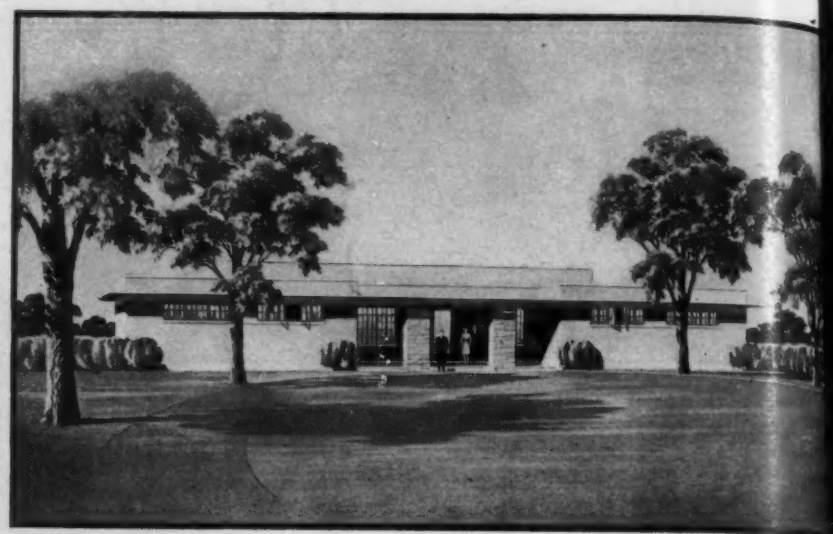


FIG. 10—Action of bevel differential drive, showing how both the main motor and the correcting motor drive the draw roll and how changing the direction of the correcting motor rotation will add or subtract from the effect of the main motor

Architect's wash drawing of the new WJZ transmitter building now being erected at Lodi, N. J., about 9 miles from Manhattan



Aerial view of the WJZ tower at Bound Brook, showing the extent of the ground system that will have to be excavated to salvage precious copper for the new site

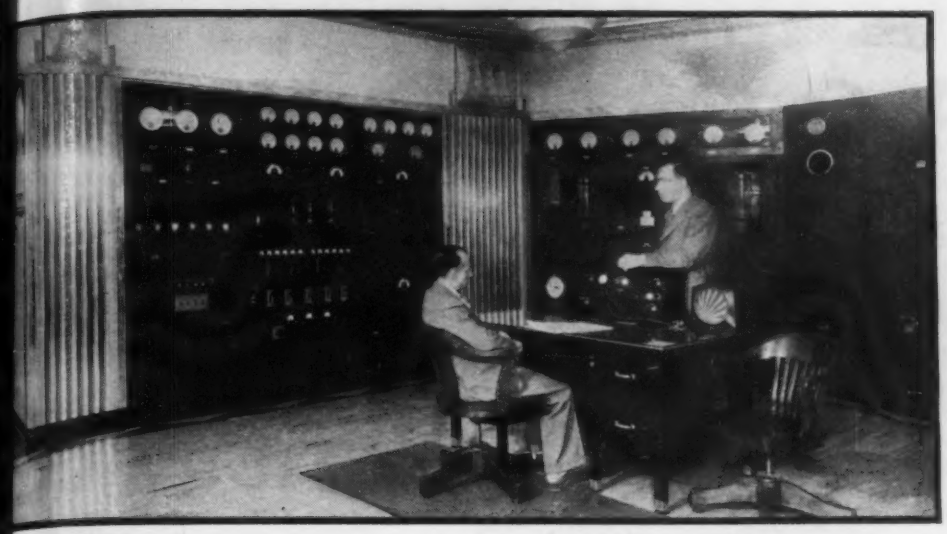
Moving a 50-kw Transmitter...W

How WJZ, New York City's oldest broadcast station, is moving its entire transmitter and 640-foot tower to a new site on the North Jersey salt marshes without going off the air, in order to make room at the old Bound Brook site for four new OWI transmitters

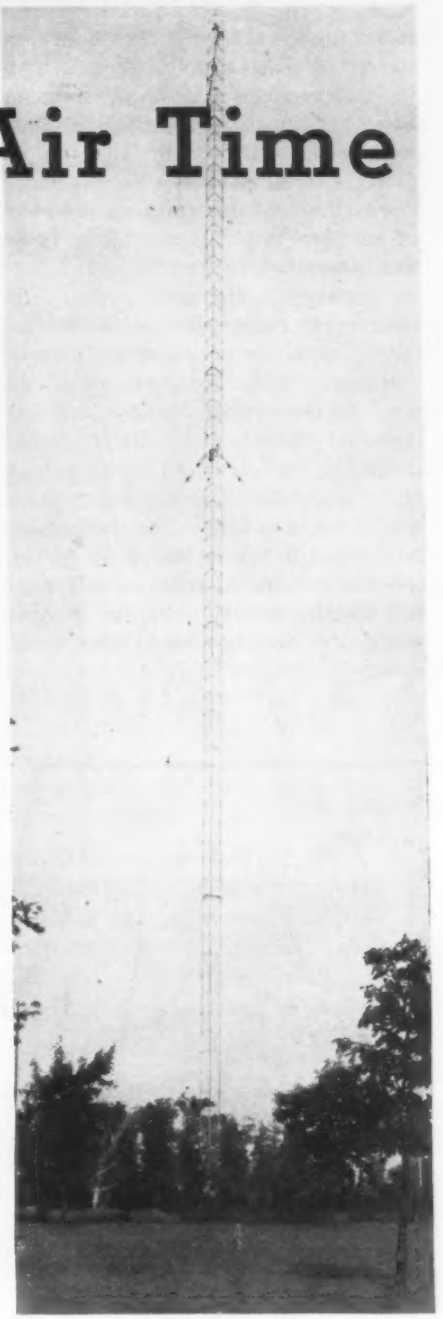
THE important role played by short-wave broadcasting in the present war has indirectly resulted in the moving of all transmitting facilities of WJZ, key Blue Network station and second-oldest broadcast station in the country, from the international short-wave broadcasting center at Bound Brook, N. J. to a new site at Lodi, N. J.

The reason for the move dates back to the time when the Office of War Information took over all short-wave broadcasting facilities in this country for defense purposes. The United States then had only a handful of transmitters powerful enough to enter the international competition of short-wave radio to South America, Europe and the Pacific. Our twelve stations had to compete with some thirty German stations, a half dozen Italian stations, and many others.

In September 1942 the construction of twenty-two more short-wave transmitters was authorized, all to be 50 kilowatts or higher in power. Locations then had to be found for the new transmitters, and buildings obtained or erected at the sites. It was highly desirable to place these new stations near or at locations of existing transmitters because of availability of power, communication facilities, trained operating personnel, antenna facilities, ample land, etc. For this reason, the decision was made to install four of the new 50-kw transmitters at Bound Brook, alongside NBC's other short-wave stations WRCA and WNBI.



This 50-kw WJZ transmitter at Bound Brook will be moved to a new site without interrupting 24-hour-a-day broadcast service and with an absolute minimum of new construction, by utilizing auxiliary equipment at both old and new sites on a carefully planned schedule



Beginning of dismantling operations on the 640-foot guyed steel tower at Bound Brook will start like this, with steel-workers at the top rigging a pole for lowering the structural members piece by piece. Steel for a new tower cannot be obtained, so this tower will be moved to the new site

Without Loss of Air Time

This decision brought forth the first problem, that of deciding whether to erect a new building at Bound Brook for the four transmitters, or whether it would be better to use the present WJZ transmitter building and move WJZ facilities elsewhere.

Investigation showed it would be considerably cheaper and more satisfactory to move WJZ and its 640-foot tower. This would give OWI all the space it needs for the added short-wave stations. Therefore, in September 1942 the Blue Network was asked to move its station, with OWI bearing the cost of dismantling and part of the cost of moving the tower and transmitter.

Choosing a New Location

With the Office of War Information backing WJZ in its application for the necessary FCC construction permit and the WPB application for essential materials required, the problem of selecting the new site came up.

Except for a two-year period (the Aeolian Hall days), WJZ had always been a New Jersey station, and the Blue Network wished to retain this association. In New Jersey are the meadows, consisting of large areas of salt marshes flushed with tidewater twice a day. These marshes provide an almost perfect ground for transmitters, with a low and level transmission path to surrounding communities and the New York district.

Large though the marshes are, extending far below and above New York City proper, the desirability of getting a signal into Manhattan as nearly as possible at right angles (so waves would travel a near-minimum distance over highly-absorptive Manhattan skyscrapers in getting to Long Island communities) precluded going too far north or south of Manhattan on the marshes. This restricted the search to an area roughly between Newark Airport and the towns of Paramus and New Milford. In this area were located ten broadcast stations already serving New York City, not to mention a large number of police, aircraft and other communications transmitters.

One of the difficulties in locating a site was the fact that WJZ's frequency is lower than that of any other broadcast station on the marshes. This meant that its tower would be higher than those of the other stations and would re-radiate their signals, appreciably altering the directional patterns if too close to other stations.

It was desirable to find a site near

(*Continued on page* 184)

An A-C Operated Vacuum Tub

Voltmeter suitable for wide range of voltage and frequency uses diode rectifier and a-c operated triode amplifier. Voltmeter is relatively unaffected by line voltage changes, requires no voltage regulator, and can be constructed for twenty-five dollars

JAMES NO
Department of
Massachusetts
Cam

ORDINARILY the amplifier incorporated in a vacuum-tube voltmeter operates from a direct-current source of plate supply. This is convenient because almost any reasonable amplification can be obtained with good stability by the use of fairly simple circuits. Furthermore the methods of determining the gain of such an amplifier are likely to be well described in any standard text on electronics. However, such an arrangement requires a rectifier-filter circuit and perhaps a voltage stabilizer, so that the complete voltmeter may become rather bulky and expensive. Since a dependable meter deflection is, after all, the desired end result, it seems logical that a useful vacuum-tube voltmeter might be devised in which the plates of the tubes are operated from an alternating voltage directly, thereby eliminating the rectifier and filter completely.

To be most useful, a vacuum-tube voltmeter should give a correct indication over a wide range of frequencies, preferably from the low end of the audio frequency band to very high radio frequencies. A vacuum tube circuit having a 60 cycle alternating plate voltage could not be expected to provide indications of voltage which are independent of the frequency of the input signal voltage. It is possible, however, to rectify the incoming voltage, whose d-c output may then be amplified by means of suitable circuits operated from an a-c source of power. A circuit of this general type can be used for measurements over a very wide frequency range.

The basic circuit of an a-c operated amplifier is shown in Fig. 1. Because of the rectifying action of the tube unidirectional pulses of current will pass through the load resistor, R_1, in the direction shown by the arrow. As the d-c value of the grid voltage, E_c, is varied, the tube can be considered to conduct current for longer or shorter periods of the half cycle for which the plate is positive, thereby causing both the average value and the root-mean-square value of the load current to vary. Such a circuit is an "amplifier" in the sense that small voltage changes at the input may cause relatively large changes in the voltage across R_1, although the form of the output voltage may not be at all similar to that of the input voltage. A current indicator placed in series with the load resistor, R_1, would register the changes in output caused by the changes in grid voltage, and if this were properly calibrated, the meter could be used to determine the value of the applied grid voltage. Such a circuit constitutes the basic element for a simple a-c operated vacuum tube voltmeter. The instrument to be described is merely an improved version of the circuit of Fig. 1.

Most vacuum tubes are constructed so that the grid potential must be negative to effect plate current cut-off. As a result, the plate current meter of Fig. 1 will indicate some positive value of plate current when the grid is at zero potential. In order to have a meter reading of zero with zero grid input voltage, some kind of balancing scheme is necessary. The circuit of Fig. 2 provides for this balance by allowing the diode, T_2, to supply a bucking current which should be equal in magnitude to that flowing in the plate circuit of the triode at zero grid voltage. By use of the tapped transformer, it is possible to have the plates of T_1 and T_2 positive during the same half cycle, which makes it possible to have

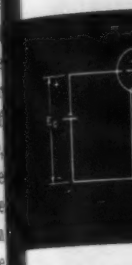


FIG. 1—Funda
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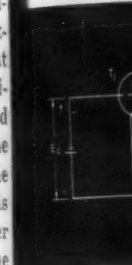

FIG. 2—A-C
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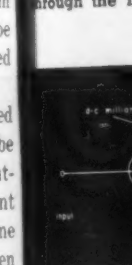

FIG. 3—Sir
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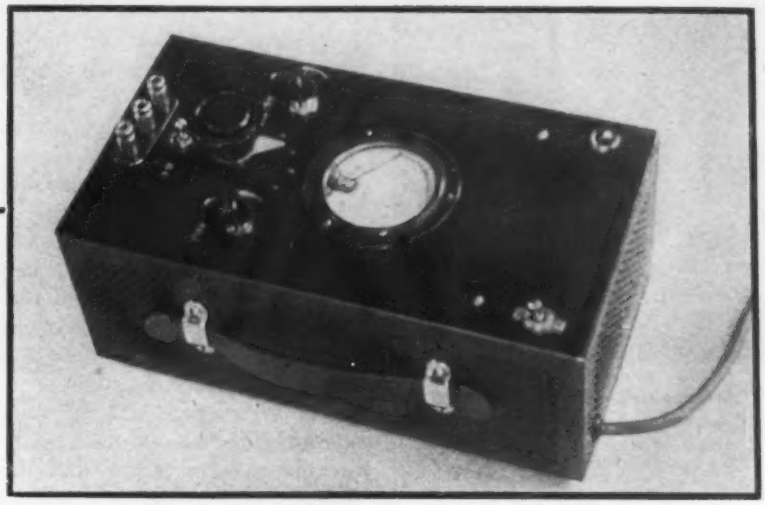
THE careful reader will discern that there is more to Mr. Thurston's article than the description of a highly useful and inexpensive voltmeter. The use of tubes with an a-c source of plate supply has wide application in many industrial devices, particularly if a tube so used is reasonably free from line voltage variations which, laboratory investigation has shown, is the case.

THE analysis of the operation of a triode with a-c plate supply, together with the graphical analysis of the behavior of a-c operated pentodes, as given in "Power Output of A-C Operated Amplifiers" by W. A. Schwarzmann in the August issue, should help stimulate interest in the further development of a-c operated electronic industrial and measuring devices.

Tube VOLTMETER

By
JAMES NORTON THURSTON
Department of Electrical Engineering
Massachusetts Institute of Technology
Cambridge, Mass.



Photograph of the completed voltmeter, ready for operation

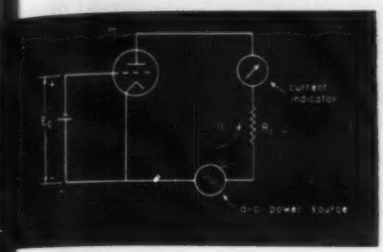


FIG. 1—Fundamental electrical circuit of the a-c operated amplifier

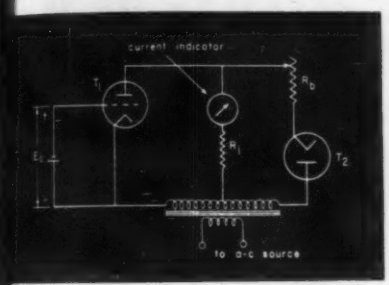


FIG. 2—A-C operated amplifier with balancing circuit to produce zero current through the meter for zero grid voltage of the triode

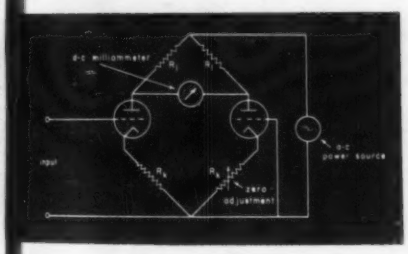


FIG. 3—Simplified schematic wiring diagram of the a-c amplifier which forms part of the vacuum tube voltmeter

the current through the indicating meter balanced to zero at all instants when zero grid voltage is applied. This instantaneous balance is not required if a d-c meter is used as an indicator, but it proved advantageous in the laboratory because it reduced the heating value of the current that passed through the meter and appeared to give a more stable reading.

The basic circuit of Fig. 2 is a thoroughly practical one for vacuum-tube voltmeter service. However, a consideration of the desirable characteristics of a vacuum-tube voltmeter for continued use in the laboratory or shop necessitated the development of circuits more suitable for this type of service than the basic circuit of Fig. 2.

Practical Considerations in Vacuum-Tube Voltmeter Design

The governing principle upon which all vacuum-tube voltmeter design should be based is that the readings must be dependable and reproducible under any ordinary operating conditions. Line voltage variations, which are always present to a greater or lesser extent, must be overcome. In the case of the a-c operated instrument, these were best overcome by the use of balanced circuits since the application of negative feedback was either very difficult or not sufficiently effective. Practical considerations ruled out the use of a regulated power supply for the voltmeter.

The characteristics of vacuum tubes used in any circuit tend to change with time and use. In addition commercial tubes vary among themselves so that the circuits in which these tubes are used may not be dependable for measurement work unless some method is devised for taking account of these changes and

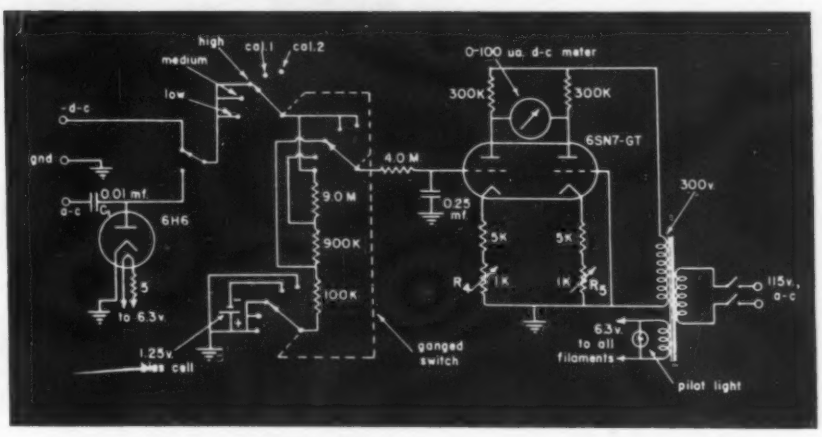


FIG. 4—Schematic diagram of complete a-c operated vacuum tube voltmeter

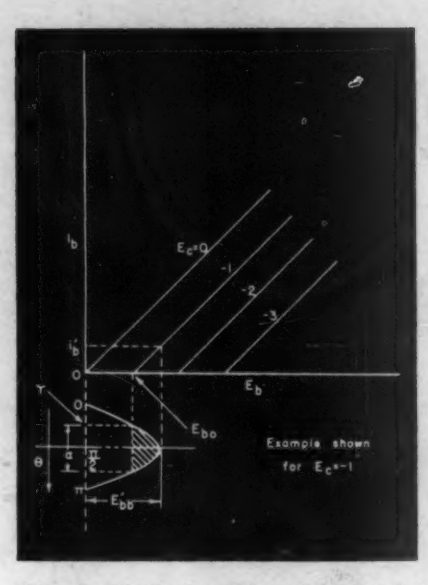


FIG. 5—Idealized triode characteristics and illustration of method of calculating output of a-c operated triode

variations. A special check-calibration method was devised to keep the instrument calibration independent of tube changes.

The indicating meter in the case of vacuum-tube voltmeters operated from d-c sources is ordinarily a d-c milliammeter or microammeter. In the case of the a-c operated vacuum-tube voltmeter, however, some question arose as to what type of meter would be most satisfactory. Laboratory work soon proved that here, also, the d-c milliammeter or microammeter was most satisfactory since such a meter would read average values of plate current. Laboratory work also showed that plate current pulses in the a-c operated amplifier could be made to give an average (d-c) reading of zero, but that the root-mean-square values of the initial and bucking current would be greater than zero. For these reasons, a d-c meter was chosen as an indicator.

In the course of the search for a satisfactory a-c operated amplifier, many interesting circuits were studied but none were as suitable for vacuum-tube voltmeter service as the arrangement shown in Fig. 3, which is a simplified circuit of the amplifier finally used in the a-c operated voltmeter.

The use of two identical tubes in a symmetrical or balanced circuit tends to eliminate changes in calibration due to line voltage variation. In actual operation the two tubes are hardly ever exactly identical and consequently a zero setting is desirable for adjusting the balance of the plate currents. Once adjusted for proper operation, however, balance is obtained over a wide range of voltage changes. The net result is to produce an indication which varies by about ± 2 percent for a line-voltage change of about ± 10 percent.

Since a double triode is used in the a-c operated amplifier, there is a tendency for cathode emission and other tube characteristics to change in the same direction in the two sections of the triode. This helps to maintain a balanced circuit. Furthermore, the use of a double triode in a single envelope saves considerable space inside the instrument.

The arrangement of Fig. 3 has the advantage of providing a meter deflection that is very nearly directly proportional to the d-c value of the voltage applied at the input terminals.

The Complete Vacuum-Tube Voltmeter

The schematic wiring diagram of the complete a-c operated vacuum-tube voltmeter is shown in Fig. 4 and a photograph of the completed unit is shown on page 103. Essentially the instrument consists of a diode rectifier, a voltage multiplier or range switching device, and the double triode balanced a-c operated symmetrical amplifier.

A 6H6 diode is used as the input tube when an alternating voltage is to be measured. One section of this tube serves as the rectifier of the input, while the other section is used. The physical dimensions of the 6H6 are rather small, which makes this tube useful in voltmeter applications since space is at a premium in an instrument of this type. A small resistor is used in series with the heater of the 6H6 to lower its filament voltage. This tends to reduce the potential which is developed at the grid of the left-hand triode section of the 6SN7-GT as a result of the initial electron velocities emitted from the cathode of the diode.

A selector switch is provided so that either direct or alternating voltages may be measured. The d-c position of this switch simply removes the diode from the circuit and substitutes the direct voltage which is to be measured for the rectified output of the diode. Whichever of these voltages is to be used is impressed across the voltage divider to which the range switch is connected. For a given meter range, this switch simply selects a portion of the voltage available and applies it to a resistance-capacitance filter, after which it is impressed upon the grid of the a-c operated amplifier.

The diode circuit and the polarity marking of the d-c input terminals are arranged so that the signal grid of the 6SN7-GT is always at zero or at a negative potential. This eliminates practically all grid current of the double triode and makes it pos

(Continued on page 224)

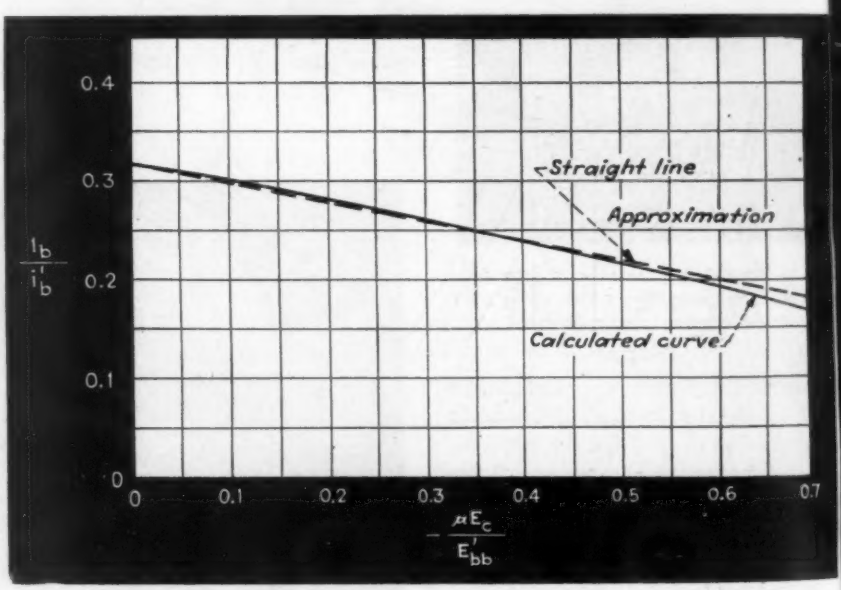


FIG. 6—Curves used in calculating direct plate current of a-c operated triodes

MINING QUARTZ IN BRAZIL

Quartz Crystals in Production

Six of the major processing steps used at the August E. Miller Laboratories of North Bergen, N. J., to convert mother quartz of ancient Brazilian riverbeds into vital crystal units for military transmitters and electronic equipment are here portrayed

RAW QUARTZ

LOCATING THE OPTICAL AXIS

WHEN OUR WORLD was in the making, one of the outstanding unions was that of a silicon atom with two atoms of oxygen, forming a molecule now unromantically called SiO_2. Colonies of these molecules assembled, governed by rigid rules. These developed into the beautiful lattice-like structure of the quartz crystals from which come the postage-stamp size slabs that today permit simultaneous operation of thousands of radio transmitters and other electronic equipment all over the world.

Mining quartz in Brazil is essentially a pick-and-shovel procedure, with native workers probing old veins or the gravel beds of prehistoric rivers by the tedious process of shovelling earth upward from one shelf to the next, then hauling it away in horse-drawn two-wheel carts.

Raw quartz as originally formed by nature is a beautiful hexagonal crystal with slightly tapered sides and many facets at one end. It must usually be broken away from the larger mass of rock out

X-RAY ORIENTATION

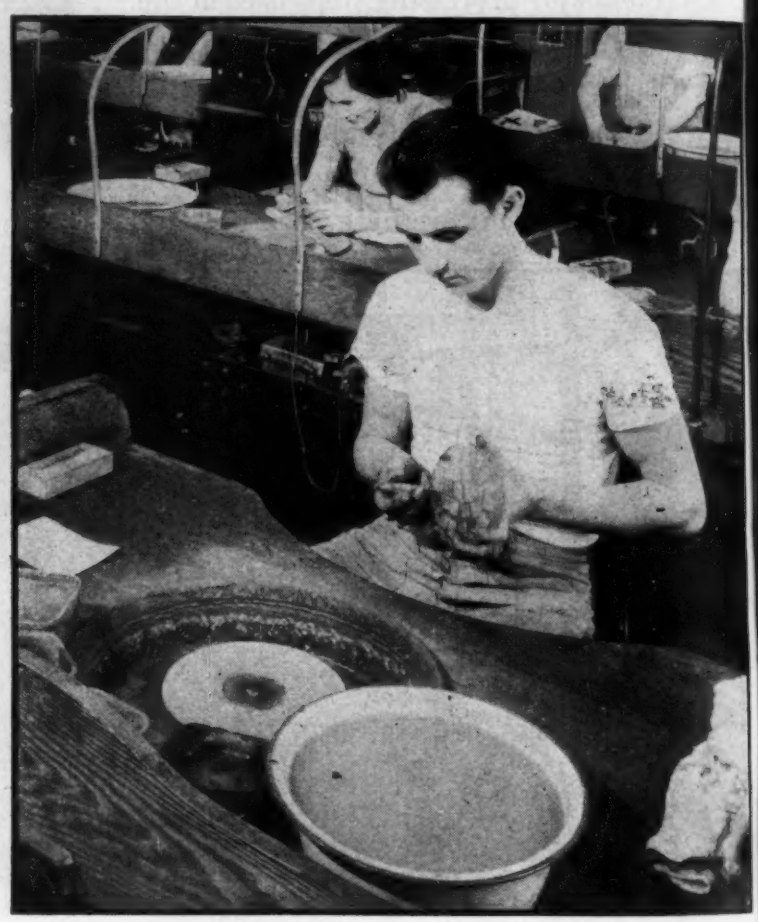
of which it has grown, hence one end will be a rough fracture. Most of the quartz coming from Brazil today, however, has rolled around for centuries in gravel beds of rivers, so that original surfaces are largely worn away by erosion.

Locating the optical axis, the first step in the preparation of a piece of quartz for cutting into radio crystal units, is done with polarized light in an instrument called a conoscope. The position is marked with crayon as a guide for the next cut. This orientation can be performed accurately even though all surfaces are worn.

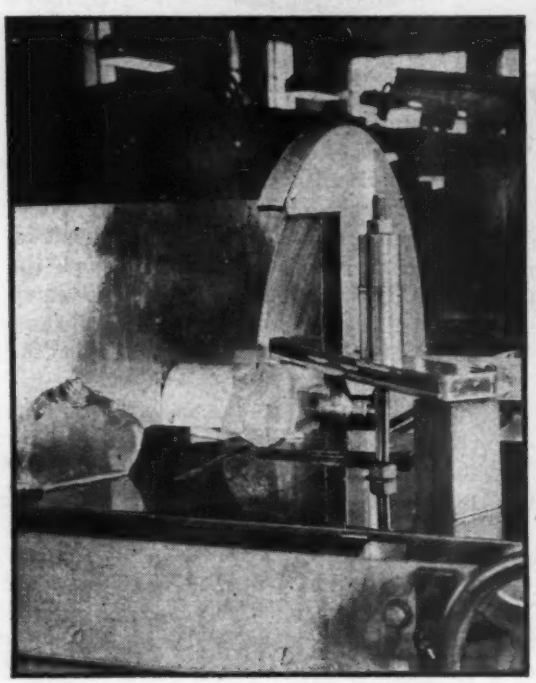
X-ray orientation serves to locate other crystallographic axes, used as guides in making the final saw cuts at the correct angles to insure that the crystal frequency will remain essentially constant over a given temperature range.

Sawing into Z sections or large blocks is done on a machine like a circular saw, using a precision saw blade having diamond teeth imbedded in its circumference. The mother crystal is clamped to the saw table, using wood blocks and wedges to position it at the previously determined correct angle. From the Z sections are sliced the wafers or blanks that go next to the grinding room.

GRINDING BLANKS



SAWING Z SECTIONS



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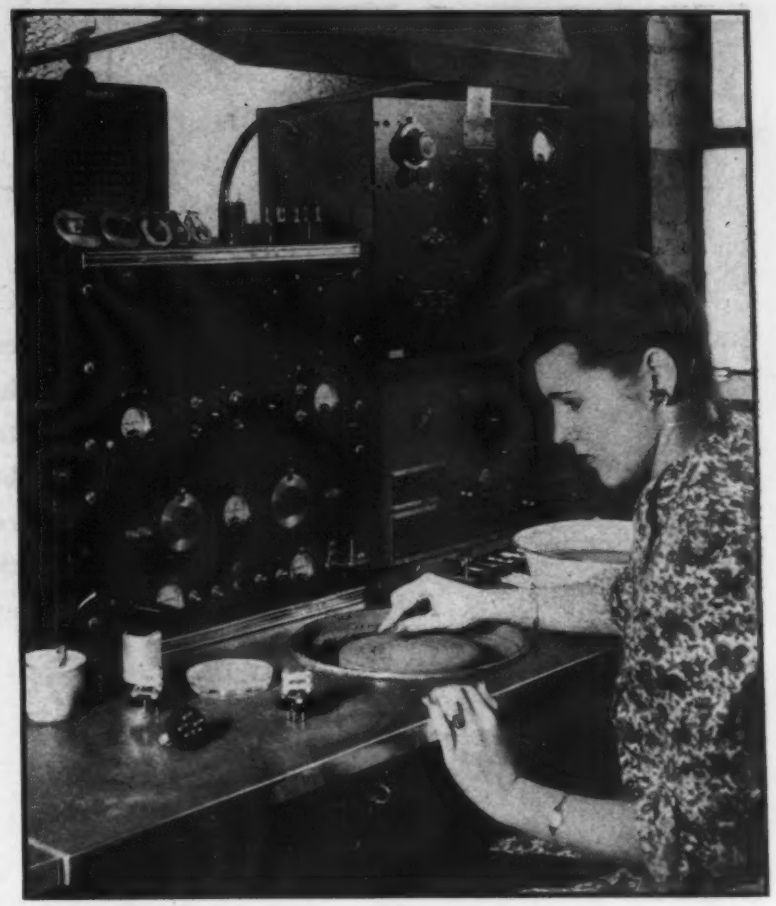
Production (continued)

Grinding blanks follows an inspection for defects. Several dozen blanks can often be mounted in a single holder and ground simultaneously, insuring flat and parallel surfaces. Frequent checks of thickness with a micrometer are essential, for the thickness is now brought to within 1/10,000 inch of its final value.

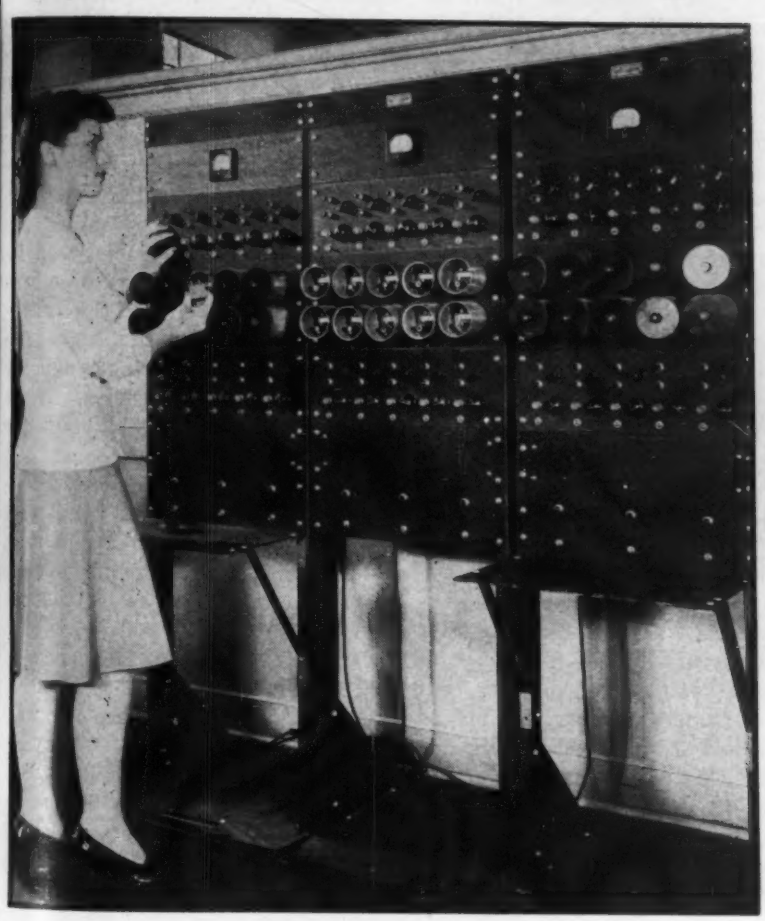
Final grinding and testing generally requires the more delicate touch of a woman's hand, for now dimensions are forgotten and the crystal is brought to its final desired frequency by alternate lapping and measurement of its frequency. This measurement is performed by inserting the carefully washed crystal slab in a holder, plugging the holder into a crystal oscillator circuit, and noting whether or not the oscillator has reached the desired frequency.

Performance tests extending over the entire range from 70 deg. below zero to 120 deg. above zero Fahrenheit are made in tiny individual ovens on racks, permit simultaneous tests of many crystals.

Finished crystal units are mounted in carefully designed holders that generally have plug-in terminals to which the electrodes on each side of the crystal slab are connected.

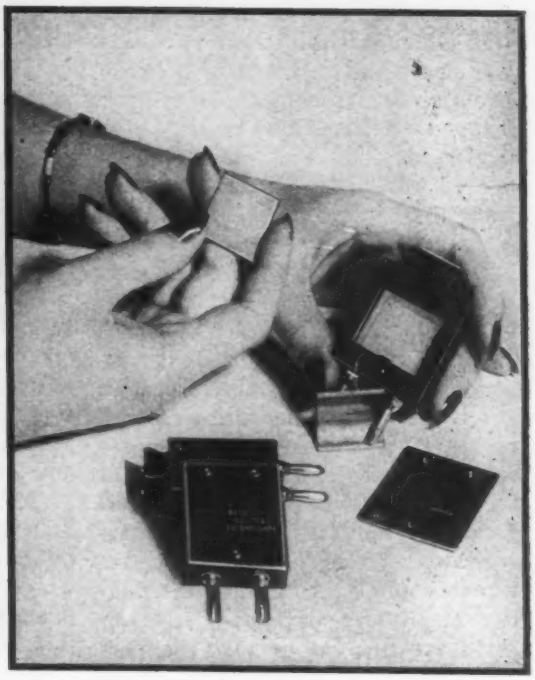


FINAL GRINDING & TESTING



←PERFORMANCE TESTS

FINISHED CRYSTAL UNITS



SPEECH SC

Front view of speech inverter for which complete circuit is given in Fig. 2. Upper dial controls inverting frequency. Two input jacks permit use with two receivers to hear both sides of a scrambled radio-phone conversation

Complete data on a frequency-inverter circuit that scientifically scrambles a human voice for purposes of secrecy in transmission. The same circuit may be used for unscrambling speech at the receiver. Five band-splitting methods that combine with inversion to insure even greater privacy are also taken up

By WILLIAM W. ROBERTS

Sperry Gyroscope Co. Brooklyn, N. Y.

IT HAS LONG been recognized that there are times when it is desirable to transmit the human voice over a telephone line or radio telephone circuit in such a form as to be absolutely unintelligible to unauthorized listeners.

Several different methods which have been employed to attain privacy for the spoken word on communication channels will be described. (The war has greatly stimulated progress in this phase of communications and many new systems have recently been developed. The details of these cannot, however, be disclosed at this time due to the dictates of military secrecy.)

In communication over ordinary telephone circuits, the instantaneous amplitudes and frequencies of the electric waves transmitted correspond to the instantaneous amplitudes and frequencies of the various sound-pressure waves making up articulate speech. These speech waves are intelligible only when the fundamental frequency components and their associated harmonics or overtones are transmitted so that the correct relative amplitudes and phase relationships are not too greatly changed. Therefore, any operation which alters these conditions materially will make it impossible to detect the transmitted waves as intelligible speech until the approximate correct relationships have been restored.

In straining ordinary speech through the medium of scrambling, the frequencies of each of the components of speech currents are changed in such a manner that, although the changed speech currents will occupy the same frequency range as that of the original speech, the essential relationship for intelligibility will have been destroyed.

Frequency Inversion

One of the simplest ways of scrambling the human voice is by means of frequency inversion. In this method, a device known as the speech inverter virtually turns a person's voice upsidedown, much as the lens of a camera inverts the image of an object in the field of vision. Everyday English becomes as unintelligible as a strange foreign language, with seemingly no apparent relation to the original speech. Yet this same incoherent jargon may be restored to normal by a similar process of inversion.

In creating inverted speech, normal voice frequencies are caused to modulate in a well known manner a constant audio frequency (inverting frequency) to produce frequencies which are combinations of the speech frequencies and the inverting frequency. These frequencies will include an upper and lower side-band which are, respectively, the inverting frequency plus the voice frequencies and the inverting frequency minus the voice frequencies. If the inverting frequency is just above the highest essential voice frequency, it will be obvious that the lower side-band will be an inverted picture of the original input voice frequencies, so that the low frequencies become highs, and the high frequencies become lows.

Using an inverting frequency of 3000 cycles, as is the case in most apparatus developed before the war, an input frequency of 200 cycles will become 3000 minus 200, or 2800 cycles in the difference frequency band. A 2500-cycle input would become 500 cycles, and all other input frequencies will correspondingly be

SCRAMBLING Methods

nverted. The upper side-band is epresentative of the original input requencies raised up in the spectrum y the value of the inverting fre- uency. In actual practice of secret elephony, this upper side-band is ttenuated by filters and only the nverse frequency band is used for ransmission.

It is rather difficult to describe the iscordant nature of inverted speech, ut anyone who has listened to the onfused mumble-jumble of a phono- raph disk reversed will get a fair idea of the type of meaningless sounds produced. The low frequencies of speech are transformed into high-pitched squeaks, while the highs and over-tones present in the voice produce a succession of low gutteral noises.

On listening to certain words spoken through the inverter, it is possible in some instances to pronounce them. For example, the words "telephone company" when translated by an inverter sound something like "playafiend crinkanope".

The inversion of music results in a jangling of tones which are particularly amusing. This process will mutilate the most beautiful symphony so that it is completely lacking in structure and composition. Increasing-pitch notes of music become decreasing-pitch notes in the inverse frequency band and vice versa.

Inverted speech has long been employed on the trans-oceanic telephone circuits to provide a limited amount of privacy against eavesdropping by short-wave radio listeners. For a higher degree of secrecy on some of the more important telephone links carrying diplomatic calls and such, a form of garbling more commonly known as band-splitting has been employed.

Speech Inverter Circuit Theory

Figure 1 illustrates a fundamental circuit for one type of speech inverter. The same circuit is applicable for both scrambling and unscrambling. It is essentially a Hartley balanced modulator or demodulator in which a pair of triodes are connected to produce certain frequencies and to suppress certain other frequencies.

The term f_v is representative of voice currents, as from an ordinary telephone set, and represents a band extending from 200 to 3000 cycles, which is considered adequate for good communication, measured in terms of satisfaction given to telephone subscribers. The term f_c indicates a sustained high-frequency carrier or inverting frequency. The impedances Z_v, Z_c and Z_L indicate the voice frequency source, inverting frequency source and the output line impedance, respectively.

Since the inverted speech will occupy the same frequency range as

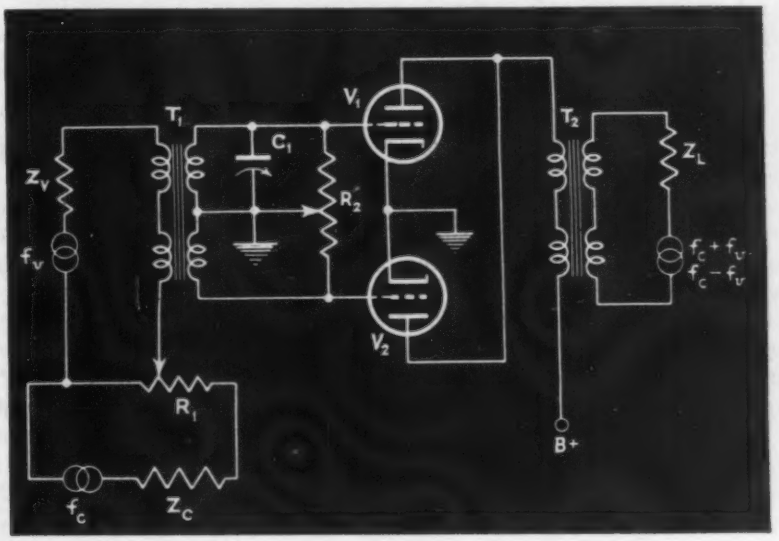


FIG. 1—Fundamental circuit of balanced modulator for speech inversion

Rear view of speech inverter. Operating voltages are obtained from a separate power pack. Intelligible audio signals fed into this unit come out scrambled, while scrambled signals fed into the unit come out unscrambled

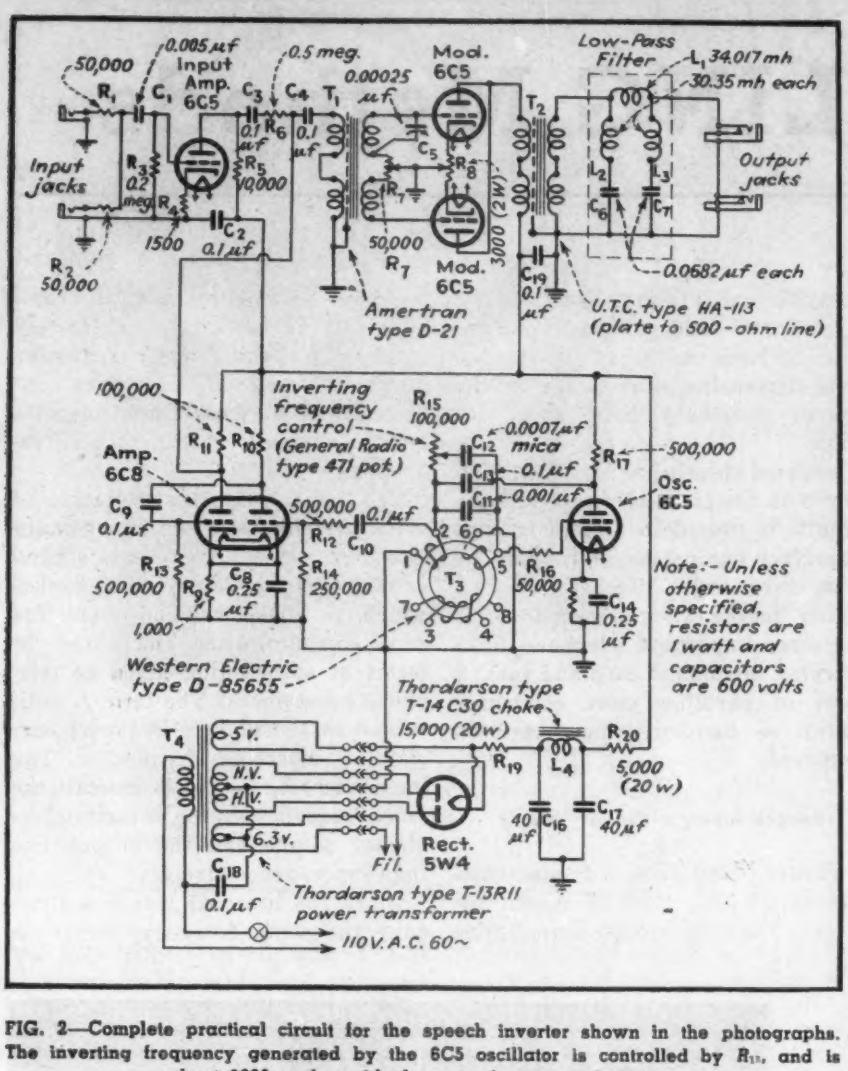


FIG. 2—Complete practical circuit for the speech inverter shown in the photographs. The inverting frequency generated by the 6C5 oscillator is controlled by R_{15}, and is about 3000 cycles with the control at its mid-position

the original speech, but in reverse order, it is essential for complete privacy that these original voice currents f_v do not appear across the output line impedance Z_L. Since the inverting frequency is near but higher than the highest essential voice frequency, it is essential that it, also, does not appear across the output impedance Z_L.

These results are secured to a high degree with the type of balanced modulator shown, producing certain frequencies which are combinations of the voice frequencies f_v and the carrier frequency f_c, but suppressing the unmodified frequencies which are the impressed waves uncombined with each other.

The frequencies produced are the upper and lower side-bands, f_c+f_v and f_c-f_v, which are respectively the inverting frequency plus the voice frequencies and the inverting frequency minus the voice frequencies. It will be seen that the upper side-band f_c+f_v is the original voice frequency band raised up in the spectrum by the value of f_c. The lower side-band f_c-f_v is an inverted version of the original voice frequencies, occupying the same position in the spectrum but in reverse order. High notes then become low notes, and lows become highs.

While the process of modulation is merely a side show in scrambling, an analysis of the interaction of currents to produce sum and difference frequencies will be interesting.

The current in the output of a three-electrode vacuum tube is assumed to be capable of representation by a power series having as an independent variable the voltage impressed upon the input circuit. That is, I_1, the output current from one such tube due to an input voltage v_1, may be completely represented by $I_1 = av_1 + bv_1^2 + cv_1^3 + \ldots$ in which a, b, c, etc., are constants depending on the tube characteristics. If another tube having essentially the same constants, a, b, c, etc., be used, the output I_2 from this tube, due to a similar impressed wave, will be substantially $I_2 = av_1 + bv_1^2 + cv_1^3 + \ldots$

It is found in practice that all terms in this series after the second power term bv_1^2 may be neglected for most purposes. It is also obvious that the first term, which simply represents the amplifying property of the tube without any frequency modification, plays no part in the modulation process. The property represented by the square term bv_1^2, however, is commonly made use of for effecting the modulation of one input wave by another.

Since one object of using a balanced modulator is to suppress unmodified frequencies, the two tubes are connected with respect to the unmodified waves so that the unmodified wave from one tube is neutralized by that of the other tube, as shown in Fig. 1. The unmodified frequencies are fed into the grids of V_1 and V_2 in push-pull. The plates form a parallel output circuit by means of the substantially zero reactance connection. With this arrangement the input wave v_1 impressed on one tube is reversed in sign relative to that impressed on the other, so that the two waves have a phase difference of 180 deg. and the output currents are added. This produces the result desired, as indicated in the following equation in which the relatively unimportant higher power terms are neglected.

$$I_1 = av_1 + bv_1^2$$
$$I_2 = -av_1 + bv_1^2$$
$$I_1 + I_2 = 2bv_1^2$$

The completeness of this action is dependent, however, upon the tubes being identical as to the properties represented by the constants a and b in the equation, and it is also dependent upon the current I_1 being completely added to the current I_2. The addition of the two output currents represents in part really the cancellation of the undesired component represented by the first power term av_1; therefore, if the current I_1 from the first tube is exactly equal to I_2 but if the adding function does not completely involve both I_1 and I_2, there will be a residue of the component av_1 appearing across output transformer T_2.

Across the secondary of T_1 is a variable resistance R_v, with the ad-

stable contact going to the common ground or cathode connection. A variable capacitor C_1 is connected in shunt with one half of the secondary winding. The purpose of this is to compensate for any inequalities in the two halves of the secondary winding and to secure a symmetrical balance of the two sides of the circuit with respect to ground.

The two tubes V_1 and V_2 should be carefully selected to have as far as possible identical characteristics. This is important, as has already been pointed out in connection with the above equations.

Potentiometer R_1 is for adjustment of the amplitude of the inverting frequency f_c, which must be large in comparison with the f_v input voltage.

In actual practice there would be included a suitable wave filter connected to impedance Z_L for selecting the inverted side-band.

Complete Speech Inverter Circuit

Figure 2 shows a complete schematic of the speech inverter shown in the photographs. The unit is complete with power supply and a low-pass m-derived filter. Two high-impedance input circuits are provided so the unit can be used in conjunction with two short-wave receivers for unscrambling trans-oceanic telephone conversations. Two receivers are necessary if one wishes to hear both sides of a conversation.

The output impedance is 500 ohms looking directly out of the low-pass filter. The two output jacks permit using two pairs of 250-ohm impedance headphones connected in series.

The 6C5 input amplifier is really a mixer stage to couple the outputs of two radio receivers to the modulator input transformer T_1. This transformer plays an important role in the circuit and should be carefully chosen. The Amertran Type D-21 was found to be satisfactory. It can be seen mounted near the top of the panel in the rear-view photograph.

In brief, to supply the grids of the two modulators with voltage at different frequencies that are exactly 180 deg. out of phase and of equal amplitude is an ideal condition but is difficult to attain in practice. A perfect balance obtained for one frequency will not be a perfect balance at another frequency.

The transformer used for T_1 must have low distributed capacitance and low capacitance between windings, and the center tap on the secondary cannot be taken from within a winding. Two leads must be brought out from separate sections of coils to provide magnetic and inductive balance.

Since we cannot have an ideal transformer, the controls R_7 and C_5 are provided to compensate for any inequalities present. The function of R_5 is to provide for balancing the plate currents of the two 6C5 modulators. All these controls are used to balance out of the output circuit the incoming speech waves and the inverting frequency from the 6C5 oscillator. They can be seen as the three small knobs across the bottom in the front-view photograph. Preliminary balancing can be aided by careful selection of the two 6C5 modulators and by interchanging them during the process of balancing. The half of the secondary across which capacitor C_5 must be shunted can only be determined by experiment.

Transformer T_2 is a standard plate-to-line transformer, and any good make will serve the purpose.

The low-pass filter is of the m-derived type to provide for suppression of the upper side-band produced by modulation. The filter is calculated with the following characteristics: $f_v = 2810$; $f_\infty = 3620$; $R_k = 477$; $m = 0.63$.

The construction of the filter should be undertaken with the following points in mind. It is essential that the a-c resistances of the various coils be kept as low as possible if sharp discrimination between the unwanted frequencies and the pass frequencies is to be obtained. Honeycomb coils may be used for the inductances since the values in this case are not very high. Choose coils of greater inductance than the values given, and remove turns while checking with an inductance bridge, until the desired value is obtained.

The capacitors can be a paper dielectric type because of the relatively low frequencies involved. The odd values given for C_6 and C_7 can be stacked up from a number of standard capacitors in parallel to provide the correct capacitance.

The inductances should be treated with wax or other moisture-resisting material. The individual inductances should be shielded from each other or spaced by their own diameter and placed alternately at right angles.

The 6C8 amplifier is perfectly straightforward and is for amplification of the inverting frequency

(*Continued on page 270*)

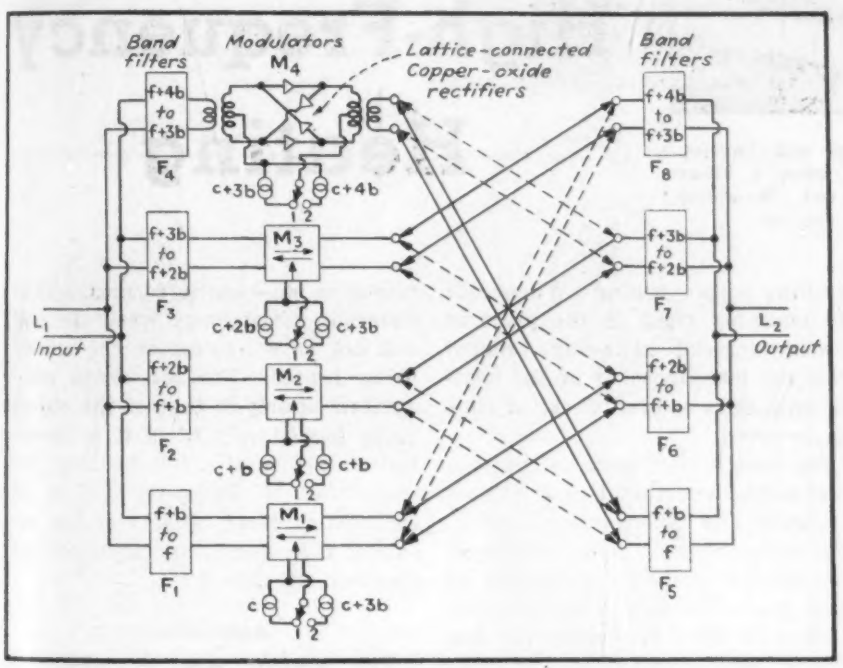
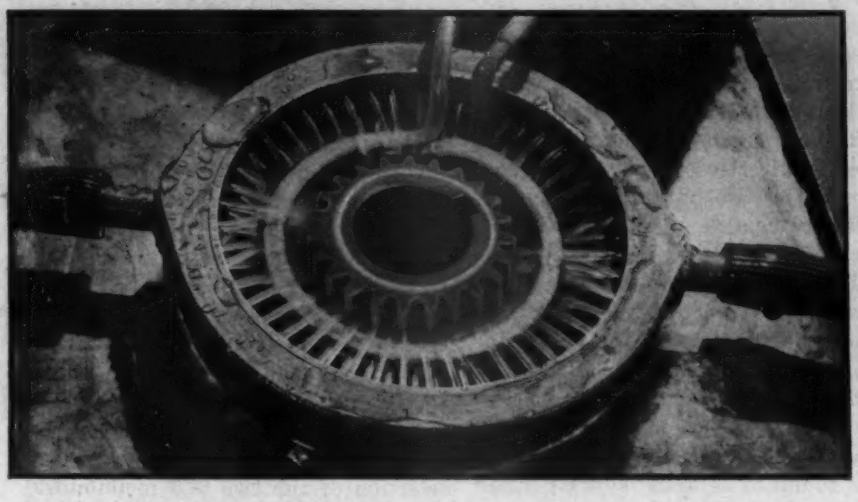
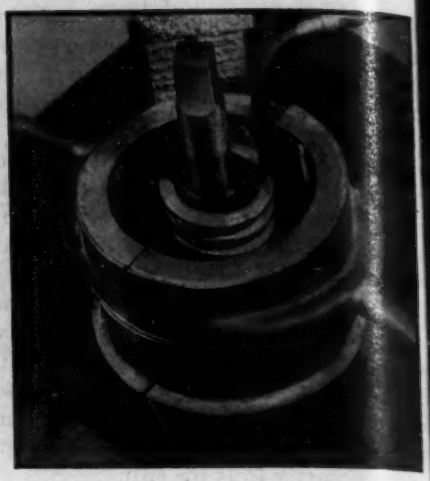


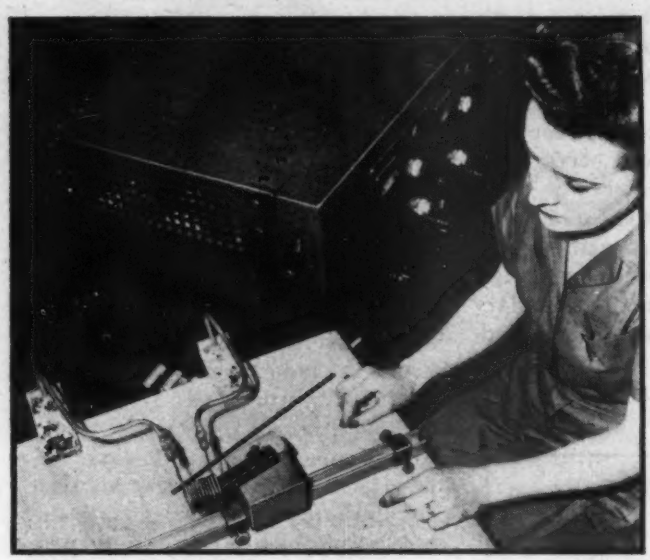
FIG. 3—Basic band-splitting arrangement for increased privacy in radiophone communication. The band filters divide essential voice frequencies into four equal bands of width b, with f being the lowest essential voice frequency. Two oscillator frequencies are available for each copper-oxide modulator to provide speech inversion. The output of each modulator may be fed to either of two filters, one passing the upper and the other the lower sideband, thus providing many possible arrangements



Quick quenching after heating, with a minimum of handling, is achieved by surrounding a work coil with a water-spray quenching ring. The turns of the coil are flattened to permit passage of water between them to get more turns in the available space



Arrangement for hardening a tap by heating only the cutting surfaces, then quenching immediately with a water spray ring



Brazing a cemented carbide tip on a steel shank with Carboloy-General Electric induction heating equipment using a 500-kc vacuum tube oscillator with a water-cooled work coil. The sliding jig positions the tool correctly inside the coil

WORK COILS for High-Frequency Heating

THE LOAD INDUCTOR or work coil of a high-frequency heating unit generally consists of a few turns of copper tubing shaped to fit around or inside the object to be heated. Water is usually forced through the tubing for cooling purposes since the coils carry heavy r-f currents and would otherwise become quite hot in continuous use. The tubing is often flattened in order to secure the desired number of turns within the dimensions of smaller objects.

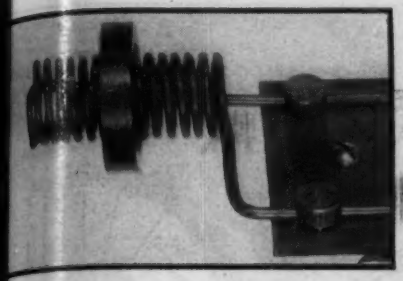
Each new shape of object to be heated generally requires a special coil. Plant engineers are discovering, however, that their own skilled mechanics are capable of making these coils after a bit of practice in handling copper tubing. When coils are made up right in the plant as needed, instead of being ordered from the manufacturer of the heating unit, days or even weeks of time can be saved.

The design of a work coil is to a great extent a combination of experimentation and experience with previous coils. The examples shown in this article, made by engineers at Lepel High Frequency Laboratories of New York City except for the brazing coils credited to Carboloy-GE, will serve as guides in winding coils for similar applications.

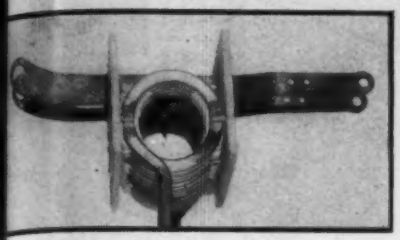
The size of tubing to be used is governed chiefly by the mechanical strength required. Small-diameter tubing is more easily formed, and is generally satisfactory when the coil will not have to support the article being heated. The coil shape need conform closely to that of the object being heated only when it is essential to utilize the full heating potentialities of the power source, as for heating large objects or for securing a desired temperature in the shortest possible time.

Applications

The general run of industrial work which can be handled with electromagnetic high-frequency heating equipment comes under three headings: Hardening and annealing; brazing and soldering; melting.



Work coil used for localized heating of the inside of a steel ring

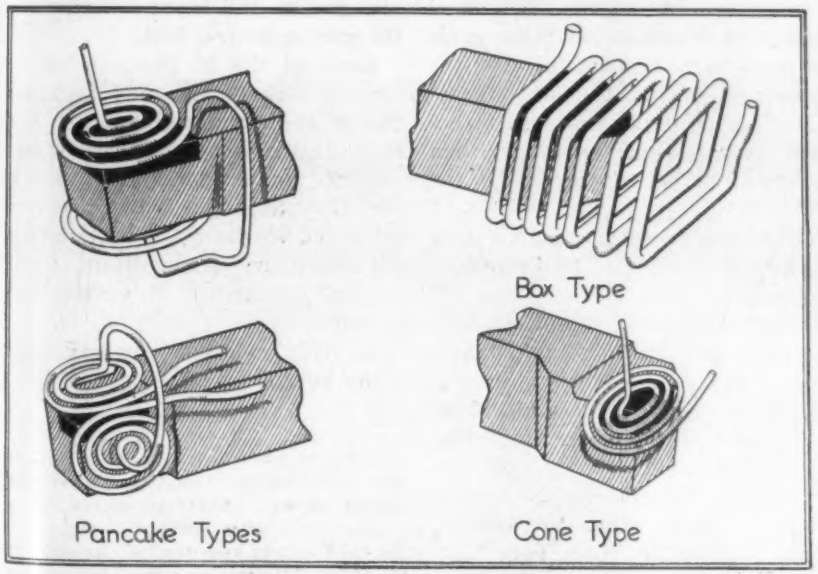


Arrangement for localized heating and hardening of the wearing points of trip levers. The heat is limited to the sections which project inside the work coil

With the work coil, quenching barrel and stock box conveniently positioned in front of the operator, localized hardening is achieved efficiently with no excess heat to create discomfort. The spark gap type heating unit being used here is made by Lepel High Frequency Laboratories, New York City

Past experience generally governs the winding of work coils which transfer r-f energy from high-frequency equipment to the object being heated. The examples given here will serve as practical guides

A plastic handle and flexible connecting leads (conductive tubing) make this work coil as convenient as a soldering iron, particularly for soldering or brazing operations on a moving conveyor. The coil is held around each object in turn until the solder or brazing alloy melts

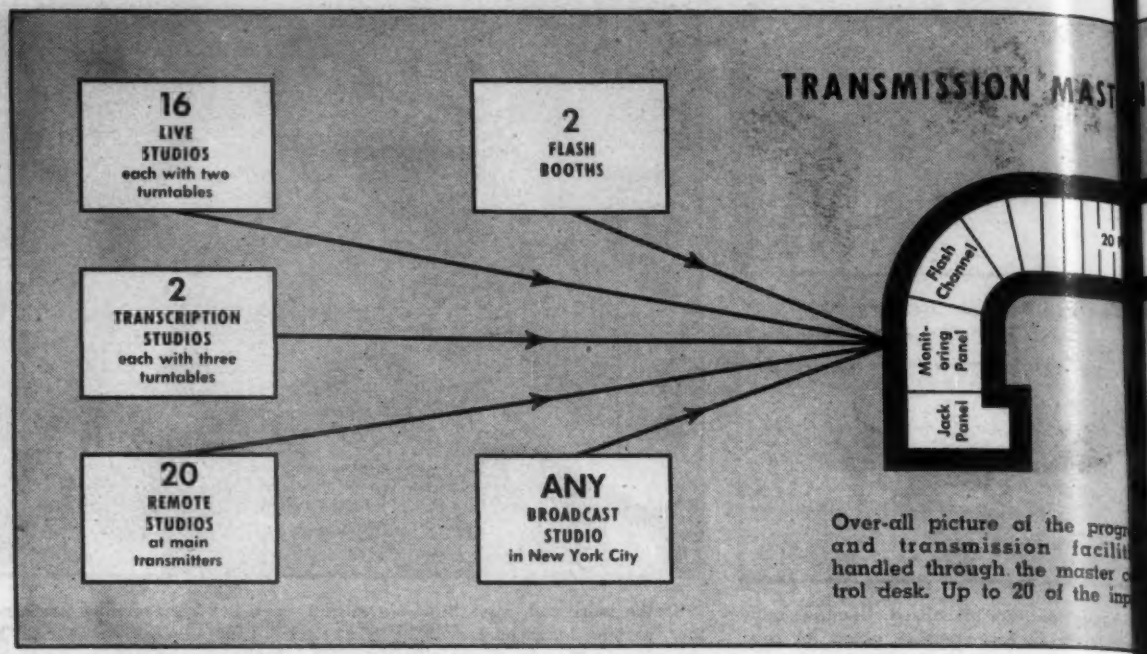


Typical Carboloy-GE work coil arrangements used in induction brazing of carbide cutting tools. When many tools are to be brazed and the heating unit has suffic capacity, several coils can be used in series to braze two or more tools at a time. The small-diameter copper tubing is easily bent to the required shape

Heating for the purpose of hardening or annealing can be produced uniformly throughout an object without too much attention to coil shape or dimensions. The frequency is likewise not critical, and can be as low as 10,000 cycles in some cases.

Surface heating is generally obtained with higher frequencies, so as to utilize more pronounced skin effects. To heat an outside surface, the coil is placed around the object. The inside surface of a hollow or ring-shaped object is heated simply by placing the work coil inside the object. Localized heating can be obtained by shaping the work coil to

(*Continued on page* 299)



Over-all picture of the progr and transmission facilit handled through the master c trol desk. Up to 20 of the inp

U. S. Short-Wave Broadcast C

New Office of War Information radio headquarters equipment in New York City can handle 20 different programs simultaneously, dispatching them to as many as 40 short-wave transmitters. All programs are automatically recorded, some for re-broadcast

WHEN the Office of War Information decided last year to lease every short-wave broadcast transmitter in the United States and feed all except a few West Coast stations with programs passing through a single OWI master control center located in New York City, a multitude of extremely complex switching and control problems was thereby created.

The main goals in designing the technical equipment for this control center were completely flexible provisions for handling up to 20 different programs simultaneously from local or outside points, switching these programs in every conceivable manner to up to 40 different transmitters within a few seconds during station-break intervals, recording every program continuously for reference, recording some programs for later rebroadcast, and monitoring of all programs by censors. The final solution that attains all these goals and many more besides, involved the design and construction of a single master control desk having more program transmission facilities than perhaps any other control desk in the world.

The completed master control desk will have 20 complete and individual channels, capable of handling 20 different programs simultaneously. Programs can originate in 16 new OWI broadcasting studios in the same building as the master control, in two special rooms for transcription broadcasts, in two "flash booths" for special announcements broken into programs, in other radio broadcasting studios in New York City and vicinity, or at any of 20 main short-wave transmitters served by this master control center. A total of 40 different program lines will be brought to the input terminals of the master control desk.

Each of the 20 channels on the control desk is assigned to a particular main transmitter. Up to 20 additional transmitters, called secondary transmitters, can also be served with any of the programs being fed to the main transmitters, but secondary transmitters cannot be fed directly by a control desk channel.

All equipment in program lines going to the 20 main transmitters

Temporary master patch board being used for switching all OWI short-wave programs pending completion of the master control desk, after which this board will be used only in emergencies. As many as a dozen different programs are passing through this board simultaneously under temporary operating conditions, necessitating carefully prepared switching charts for each quarter hour

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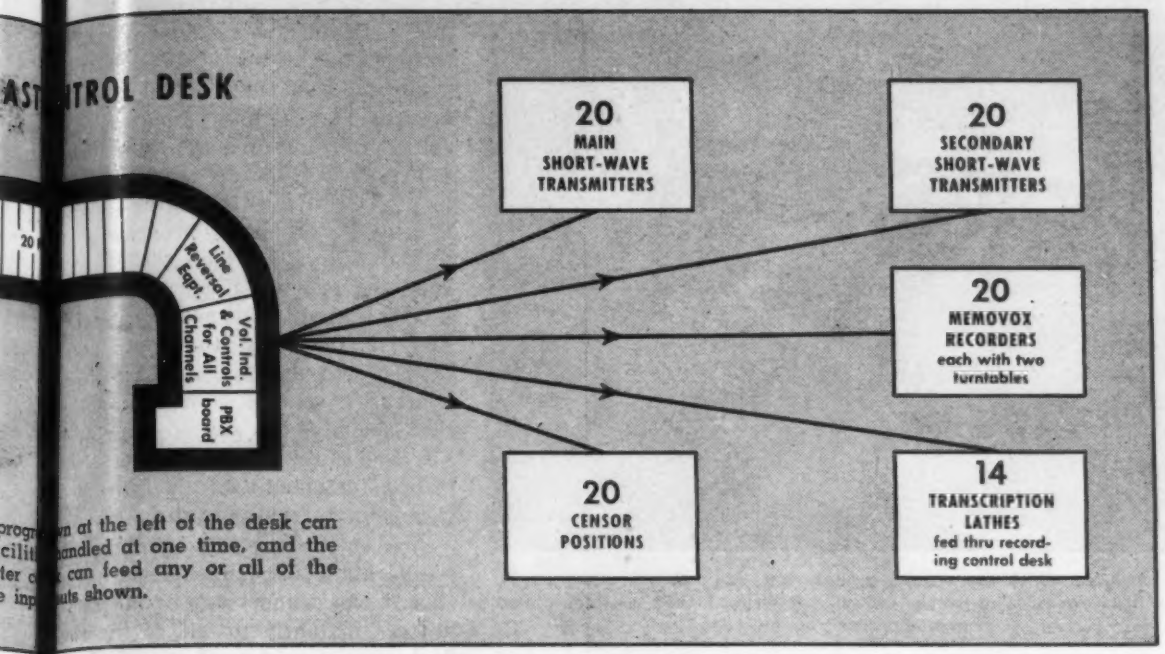


n at the left of the desk can handled at one time, and the can feed any or all of the uts shown.

CONTROL CENTER

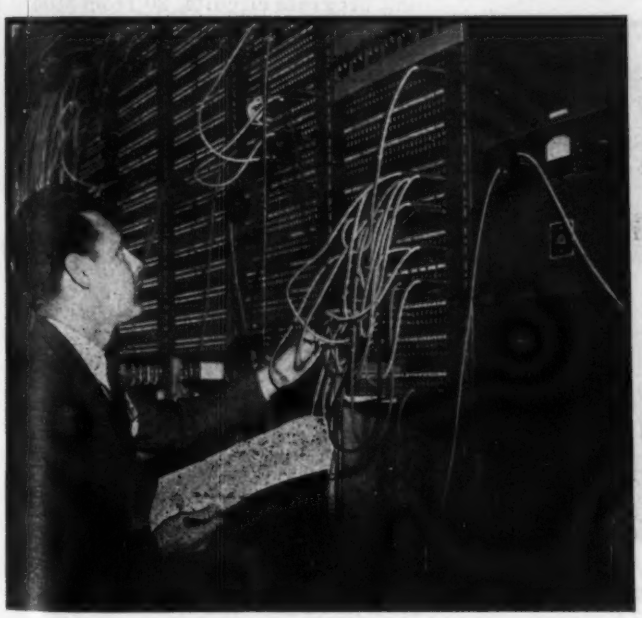
can be reversed from the control desk by means of controls on the line reversal equipment panel, to permit feeding programs over these lines in the opposite direction when desired (from a main transmitter into the control desk).

Transmission Master Control Desk

Each channel on the master control desk contains a total of 47 relays. These switch the channel input to any one of the available program sources, switch the channel output to any number of paralleled transmitter lines up to 20 that are taking the program of the channel, and provide other necessary switching functions. These relays are the recently developed Western Electric type U, capable of handling up to 13 pairs of contacts in a variety of arrangements.

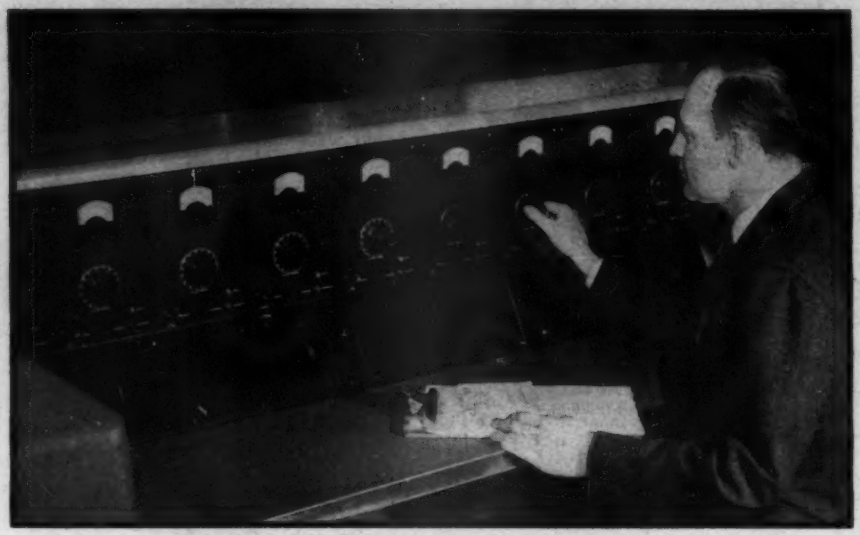
All relays and controls can be preset, so that all 20 channels can be switched simultaneously to an entirely new set-up of program sources and transmitter arrangements within a few seconds on the quarter hour, half hour or hour. There are 61 indicating lights per channel on the master control board to show pre-set and on-air connections.

Additional switching is accomplished with 25 type 479 Western Electric 3-position keys per channel

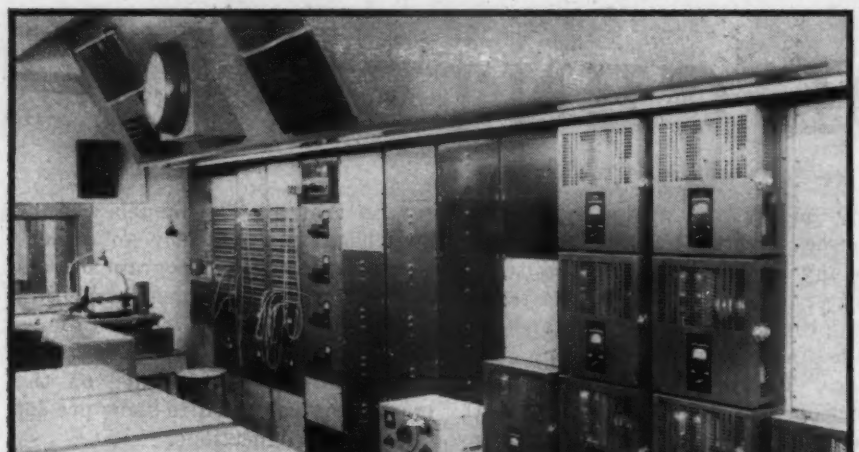


EQUIPMENT SUMMARY

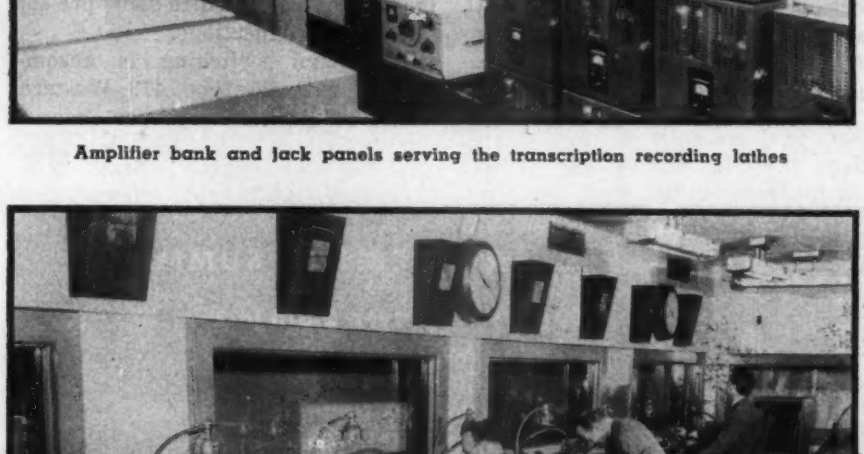
10,000 W.E.Co. type 218-A jacks
1000 W.E.Co. type U relays
350 W.E.Co. standard relays
80 RCA type 85X isolation amplifiers
60 RCA type 83D line amplifiers
56 RCA type 12236 cue amplifiers
46 W.E.Co. type 104-B preamplifiers
44 RCA type 70-C transcription turntables
40 Memovox recording amplifiers
24 W.E.Co. type 118 amplifiers
20 W.E.Co. type 105 program amplifiers
16 modified W.E.Co. 23-C studio amplifiers
14 W.E.Co. type 1087 power amplifiers
14 RCA type 73A recording lathes
4 W.E.Co. type 1126 compressing amplifiers



Recording control desk, at which the recording supervisor can take as many as 14 different programs from transmission master control and dispatch them to transcription recording lathes



Amplifier bank and jack panels serving the transcription recording lathes



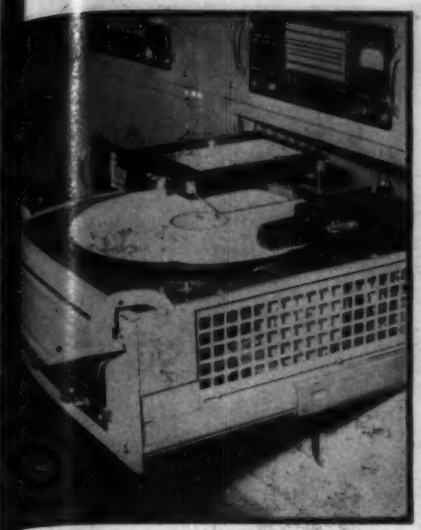
View of recording room, showing recording lathes used to produce high-fidelity transcriptions of programs for future rebroadcasting. Each lathe is rubber-mounted on a 700-lb block of concrete

and with an 8-pole, 25-point rotary switch that makes a selection of a program from one of 20 possible sources, feeds interlocked battery voltage to the studios to operate their relays, feeds interlocked battery voltage to section interlocking relays and feeds automatic program cues to the studio to which the channel has been pre-set. Each channel has a volume control for use when necessary in changing the input level from a program line, and each channel has a volume indicating meter that can be set to any of three lines for level checking, but these facilities are primarily for checking purposes, not for riding gain.

Also on the master control desk is a separate flash channel, so arranged that it can connect any or all transmitters instantly to one of the two flash studios next to the master control room without disturbing channel settings at the master control desk. Normal conditions are completely restored after the flash announcement. It should be pointed out, however, that any announcement of this nature must first be cleared through Washington censorship, and hence does not correspond to the flash news announcements of broadcast stations.

A monitor panel on master control serves three RCA type 64B loudspeakers mounted on the wall facing the control operators. Rotary switches connect two of the loudspeakers to any of 80 different program circuit positions in the building. The third loudspeaker is connected to a Strowger dial system that provides a choice of 100 different program circuits, 20 from studios in the building, 20 from receiving lines, 40 from program channels going out to the prime and secondary transmitters, and up to 20 additional audition, receiving and other circuits.

At one side on the master control desk is a complete PBX telephone switchboard for the control operators, permitting quick communication with any point at which trouble may develop in the vast OWI broadcasting system. This is handled by the transmission operator, who also checks levels of incoming program channels, checks reversing equipment regularly, and keeps up the log containing data on master control setups to the various program sources and transmitters at each minute of the 24-hour operating day. Two operators handle ten channels each at



One of the two turntable drawers in each Memovox unit. Switching between turntables is automatic. Each turntable can emboss a one-hour program on one side of its flexible plastic disc, hence the units can run unattended for two hours at a time

Memovox recorder units, one of which is provided for each program channel on the master control desk, to obtain a reference recording of every program put on the air by OWI. The recorders start up automatically whenever a channel is energized

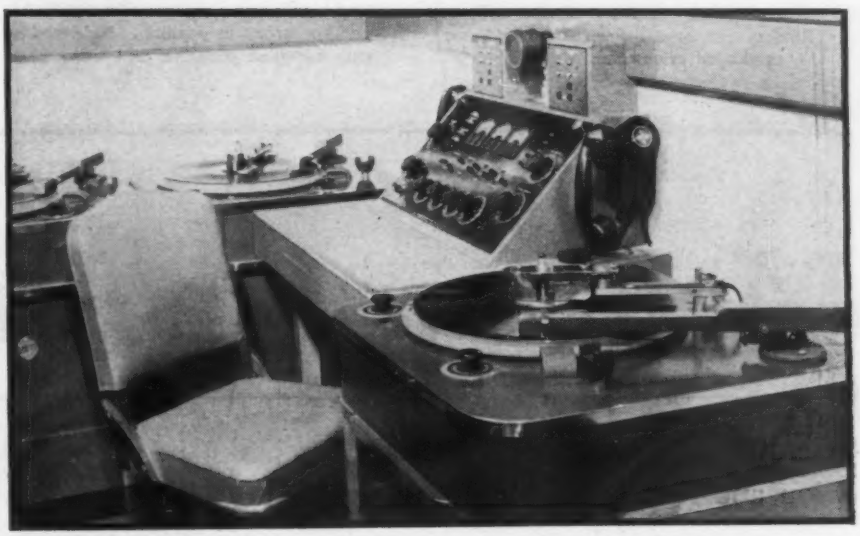
the control desk, and an additional man serves as control room supervisor.

Master Control Room Equipment

Along the walls of the master control room are 18 racks, containing approximately 8,000 jacks for patch cord connections, 60 RCA type 83D line amplifiers, 80 RCA type 85X isolation amplifiers, four Western Electric type 1126 compressing amplifiers to reduce level peaks that are particularly predominant in certain foreign-language broadcasts, four Western Electric type 118 monitoring amplifiers, and two recording volume indicators with associated amplifying and rectifying equipment for spot monitoring of levels to check the work of studio operators and to place any desired circuit under observation.

One cabinet contains the Strowger assembly for the entire system, including 36 100-position 2-motion relays with associated control relays for the 36 Strowger dial stations placed at strategic points throughout the building. At each dial station, the program at any of 100 different points in the building may be selected and fed to a monitoring loudspeaker.

Each of the censors that check the programs continually in the building has an indicating light on the master control desk corresponding to the channel he is checking. When this light comes on, the control operator knows that the censor considers a program objectionable, and takes it off the air until the censor's light goes out to indicate that the program is clear again.



One of the transcription recording rooms. It can handle three transcribed programs simultaneously with only a single operator. Electromagnetic brakes hold each transcription stationary with the pickup in the selected position, with the turntable rotating continuously and the record slipping, so the operator can start all three programs at the same time by releasing the brakes

All in all, the operators at the master control desk have a total of over 1500 indicating lamps and 20 meters to watch while listening to three loudspeakers that may be blaring forth in three different languages simultaneously.

Studio Facilities

Each of the 16 new OWI studios in the building has its own control room, containing a Western Electric type 23C program amplifier modified for master control interlocked switching and with the number of channels increased from five up to seven to permit studio-to-studio cross-feed and give two turntable channels. The modified amplifier therefore has five low-level channels and two-high-level channels, and permits a choice of three cross-feed channels when programs from more than one studio are to be mixed together on a single program. The control room amplifiers have complete test channels, permitting cue testing of other channels while one channel of the amplifier is on the air.

(*Continued on page* 301)

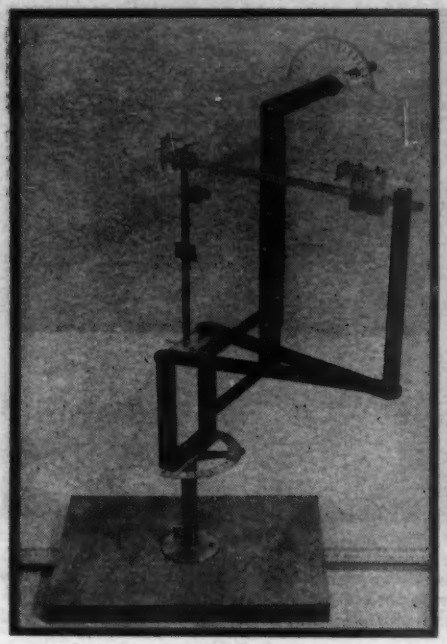


FIG. 10—Bakelite frame for receiving antenna with receiving dipole and reflectors mounted. Protractors indicate angles of orientation of antennas

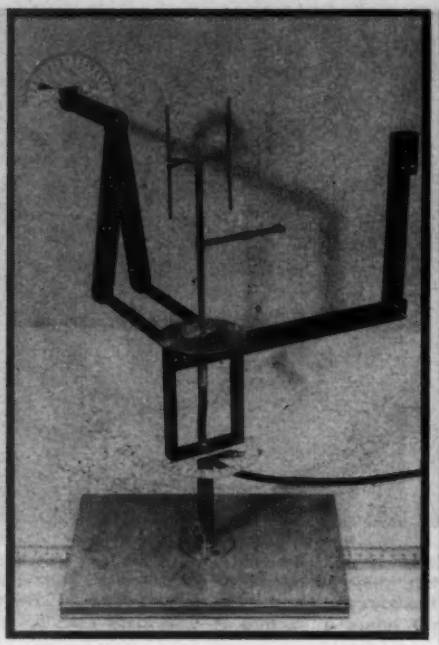


FIG. 11—Frame for transmitting antenna with two-element collinear double end-fire array in position. Note sliding stub between antenna and base plate

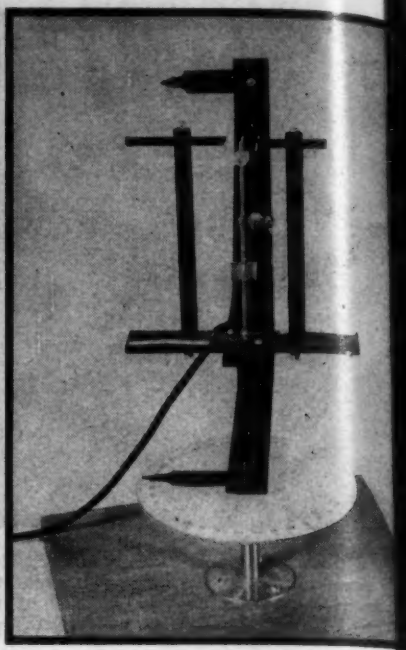


FIG. 12—Receiving antenna with movable director and reflector. The antenna may be mounted horizontally, as shown in this photo, or vertically

PART 2

MICROWAVE PLUMBING

Microwave antennas, easily constructed and used in the laboratory, simplify studies of radiation and propagation. Effects produced at longer waves can be ascertained by treating microwave antennas as models

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THE operating mechanism of an antenna and its distant field furnish two more or less distinct topics for study. In order to investigate the distant field patterns of antennas, one should be in the radiation zone (several wavelengths away) with the receiving unit. A wavelength of 10 cm is therefore used to permit the measurements to be taken in laboratory and lecture rooms of normal size. Pipes and other large metal objects along the walls of the rooms give very little interference at this wavelength.

On the other hand, investigation of the current distribution along an antenna and associated feeders is more feasible at the longer wavelength of say one meter. It may well be worthwhile to duplicate the same antenna system for the two applications.

Receiving Antenna Frame

The universal holding frames of Figs. 10 and 11 are designed for use at a wavelength of 10 cm. Two support posts and scales are mounted on each frame. Vertical and horizontal field patterns may be taken by inserting one or the other of the two posts in the base. The transmitting and receiving assemblies are arranged to slide along a common track to give accurate alignment and separation.

The receiving frame (Fig. 10) contains a section of parallel line at the bottom of which the microammeter leads are attached. The crystal holder and shorting capacitor may be moved along the line to match the load. The top is threaded to take the desired fixed or adjustable antenna rods. In the illustration a polystyrene block has been fitted

Editor's note: Part 1 of this article, dealing with transmission lines and wave guides, appeared in the Sept. 1943 issue of ELECTRONICS.

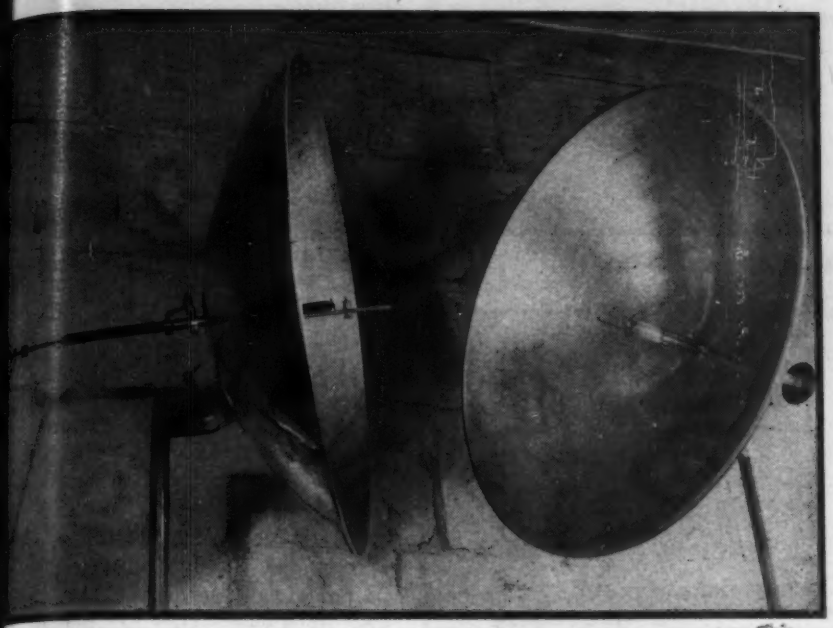


FIG. 13—Paraboloidal reflectors of spun aluminum. Receiving unit, at left, has crystal and capacitor at extreme left. Coaxial line mounting disk is shown at extreme right of transmitting unit. Both antennas use reflector elements to eliminate forward radiation directly from the antenna, so all radiation will be from reflectors

ate the cross-over gives the same type broadside array. Multi-element collinear, single end-fire, and other arrays, as well as loops and parabolic reflectors may be mounted in the frame. The lengths of the driven units are critical in these arrays and must be calculated in advance for good performance.[1]

An alternative design for the mounting frame is shown in Fig. 12. The single director and reflector may be moved more readily and are equipped with scales to locate their positions at each setting. The usual crystal and capacitor are mounted on the supporting line of the central (receiving) antenna.

Parabolic Reflectors

Paraboloidal reflectors such as were used in microwave transmission across the English Channel some ten years ago have also been used with success at the 10-cm wavelength. The spun aluminum units in Fig. 13

over the line to support a frame for parasitic antennas. Rods of adjustable length may be inserted in the polystyrene holders which, in turn, can slide along the supporting rod. The photograph of Fig. 10 shows a quarter-wave dipole and single director in place; a few reflector frames, one with its reflector element, are pushed back to minimize their effect.

Transmitting Antenna Frames

The transmitting frame in Fig. 11 is of similar construction. A coaxial feeder is attached to the circular base plate of the parallel section. This brass disk acts as a detuning device to prevent unbalanced currents from flowing on the outside of the feeder. Further mention of this effect will be made later. A sliding adjustable stub is provided for matching, and the top of the line is again threaded to take the antenna rods.

Aside from simple antennas which may be mounted with or without parasites as in the receiving frame, a number of special arrays have been constructed. The one shown is a two-element collinear (full-wave) double end-fire (lazy H) array. Rearranging the curved rods to elimin-

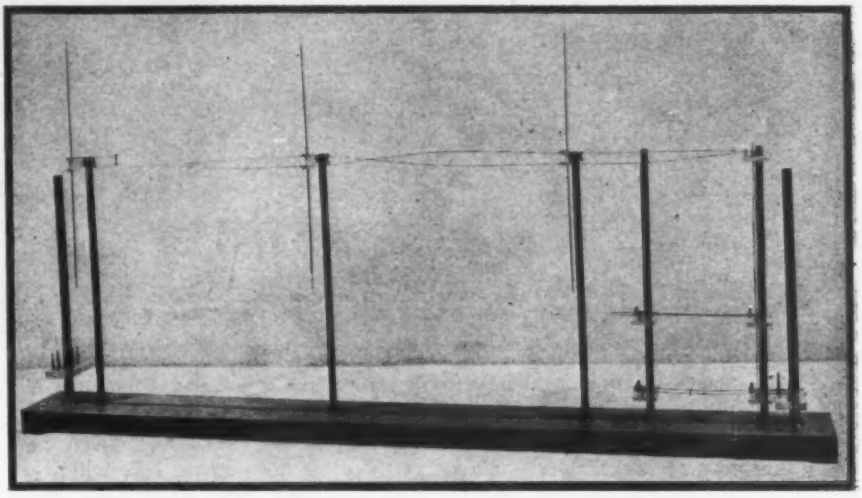
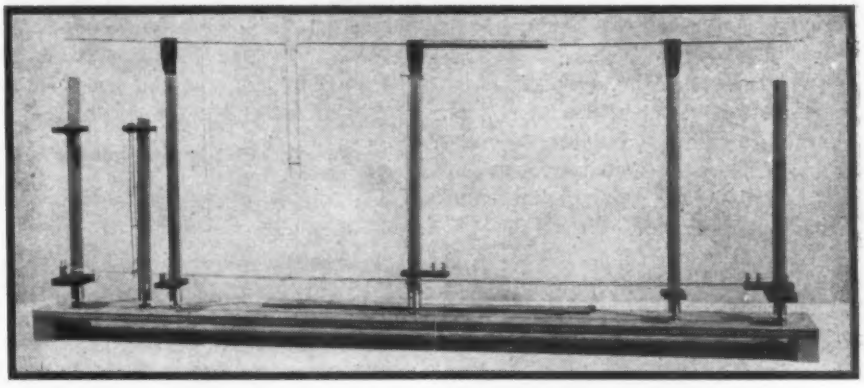


FIG. 14—Three-element broadside antenna array. Antenna length can be adjusted by telescoping brass tube sections of which antennas are made. Proper phase relations are obtained by transposed feeder

FIG. 15—Three-element collinear antenna array, showing two types of phase-reversing devices



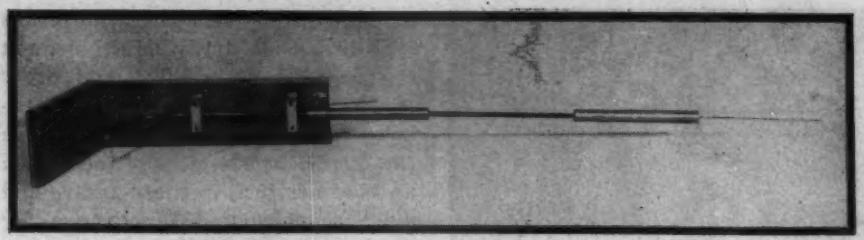


FIG. 16—Three-element collinear antenna with coaxial feed

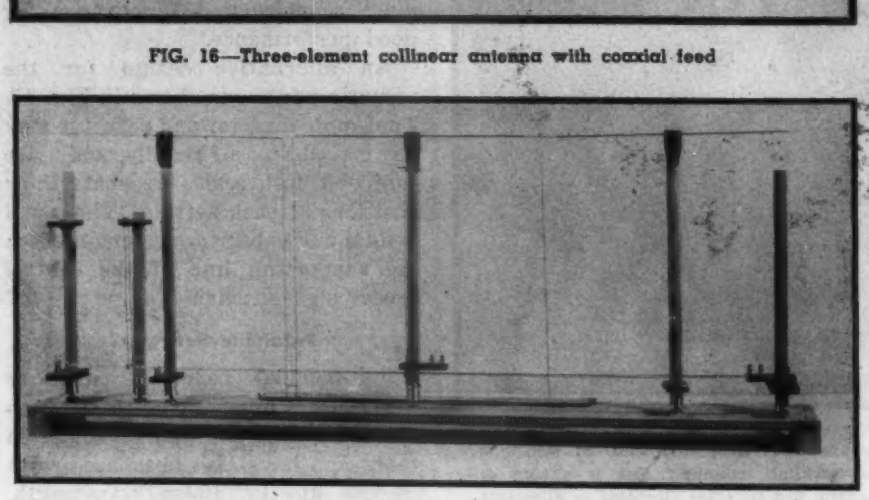


FIG. 17—Coupled antenna constructed from same elements used to build up antenna of Fig. 15. The half-wave section resonates as a whole

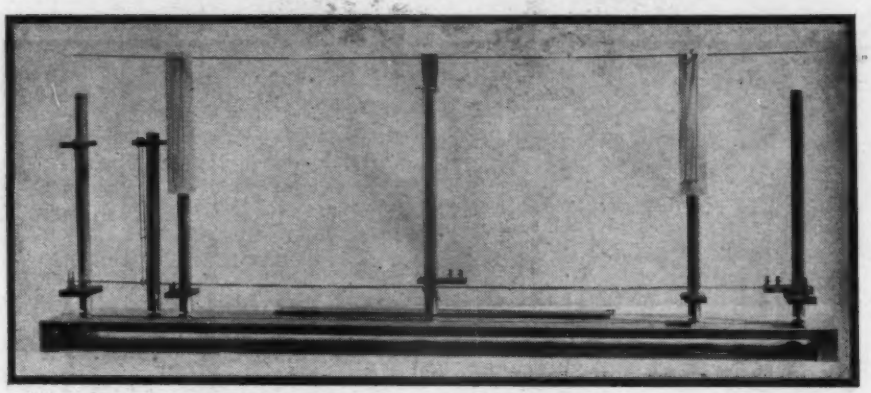


FIG. 18—Coupled antenna, with open quarter-wave stub at left and closed stub at right for detuning

are mounted on heavy tripods whose center column may be rotated to permit directivity measurements.

The antenna support shown consists of a dielectric rod pierced by a parallel line. The cross-section is shaped like two slightly overlapping circles, with the feeder rods at the points of intersection. A spacing of 1 mm in polystyrene gives a characteristic resistance of some 80 ohms for the feeder line, which has ⅛-inch conductors. This low value of characteristic resistance provides a matched load for the coaxial cable from the generator.

The closely spaced parallel line is perfectly suited for coupling to a center fed antenna and gives a symmetrical pattern, which the alternative coaxial mounting on the antenna in Fig. 9 does not. The whole assembly can slide back and forth through a hole at the vertex of the paraboloid.

In the receiving unit (left in Fig. 13) the antenna assembly may be rotated on its axis as well. A single reflector is used in front of each antenna to eliminate direct radiation; crystal and capacitor are visible at the extreme left, and the coaxial line mounting disk is at the right.

Arrays for 1-m Wavelength

The longer wavelength arrays present a somewhat different appearance. The mountings are arranged to permit tilting of the upper insulating support as well as rotation and sliding back and forth of the posts. The feeder line is equipped with double stubs for accurate matching of the load to the generator, which is essential for adequate power transfer. A three-element broadside array with transposed feeder to give proper phase relations is illustrated in Fig. 14; the antennas are adjustable in length.

A three-element collinear array in Fig. 15 is connected unsymmetrically to show two phase-reversing devices. In practice only one type would be used. The left side uses a quarter-wave closed stub, the right-hand one a coaxial sleeve. Note the movable matching stub at the top of the center feeder for properly terminating the line. In this case the line is so short that only one matching device is required, but both units are kept in the circuit to show their use in long lines where they are needed.

A coaxial version is shown in Fig. 16. With the open ends of the reversing sleeves facing down, the unit is a two-element collinear array; mounting the bottom sleeve with open end up gives a center fed antenna with a detuning section for the outer surface of the feeder.

Coupling and Tuning Problems

The ramifications of coupling devices of this sort are demonstrated in Fig. 17 and Fig. 18. The half-wave section at the left in Fig. 17 can resonate as a whole and does. This "antenna mode" dominates, and the effect is thus the same as that of the single rod connected at the right. In general, transmission line theory is inadequate where the section is of correct length to resonate as a whole with the antennas to which it is connected. On the other hand, correct adjustment of the open quarter-wave stub at the left of Fig. 18 gives the same effect as a shorting bar across the top. Here the line mode is the only possible one since a quarter wavelength is too short for self-resonance. Likewise, the quarter-wave closed end stub detunes the part of the system to the right of the stub, acting in the same fashion as a very high resistance.

The tuning of these antenna circuits is delicate since the stubs must present essentially a pure resistance and be inserted exactly at a point of current maximum without them. A small bulb as a tuning indicator has the disadvantage of being a large load in itself, therefore altering the tuning of the element to which it is

applied. In general, a probe antenna with crystal and microammeter is to be preferred both for tuning the system and to demonstrate current distributions. A more detailed discussion of the principles of coupled antennas of this type has been published elsewhere.[3]

All but one of the antennas discussed were of the symmetrical center-driven type which lends itself to parallel line feeding. Coupling to such a load with a coaxial line which is itself not symmetrical may cause considerable difficulties. In order to prevent the outside surface of the line from carrying unbalanced currents, detuning sleeves must be used

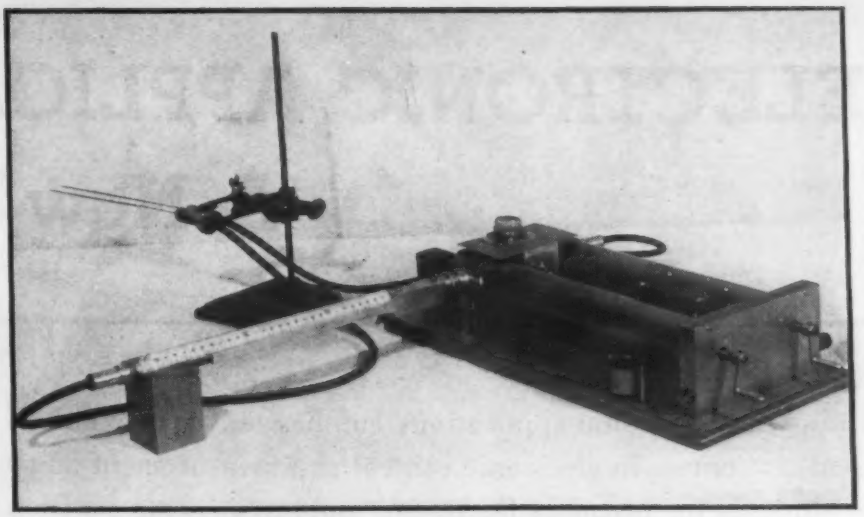


FIG. 20—Microwave oscillator employing single acorn tube and double coaxial tuning elements

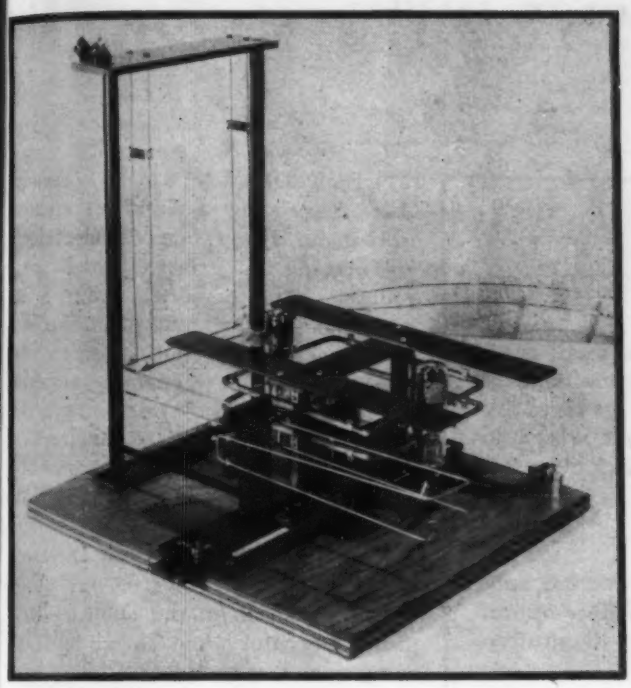


FIG. 19—Two-tube parallel-line oscillator for microwaves

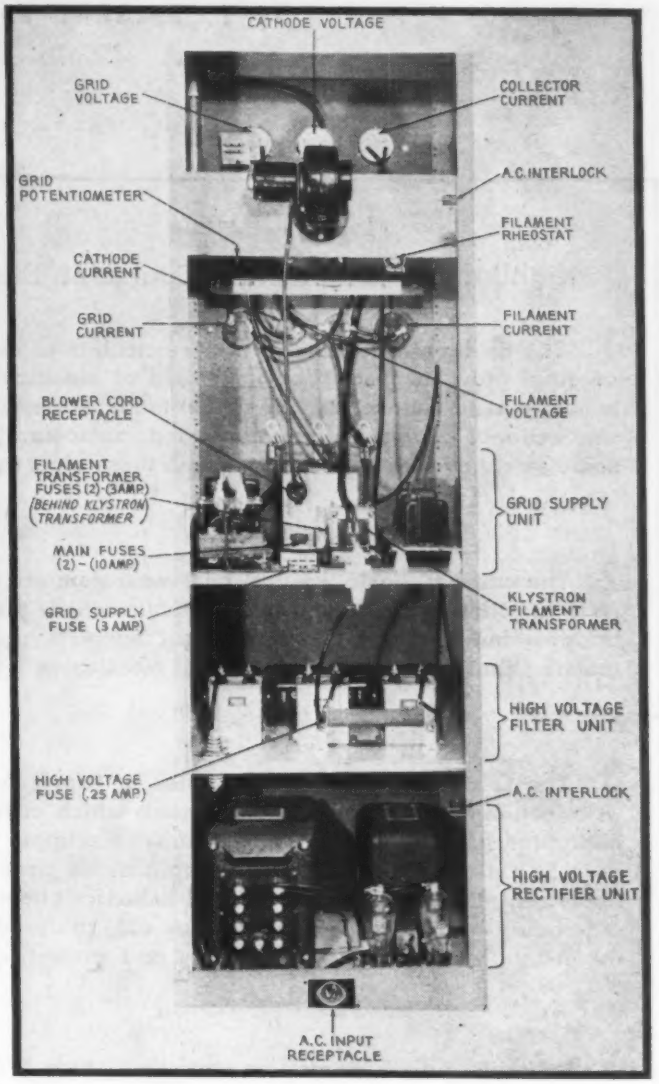


FIG. 21—Rear view of rack and panel mounted klystron oscillator

as for the coaxial collinear antenna of Fig. 16. These are cumbersome where flexible cables are used. The General Radio u-h-f oscillator used to drive an antenna, for example, has a large outside surface which includes the outside of the coaxial cable and the metal case of the oscillator itself. Unbalanced currents due to the field at the end of the coaxial line (at the unsymmetrical antenna coupling unit) may excite this surface so strongly that considerable radiation is observed from it. The surface is large enough to have several possible modes of oscillation, and consequently it is usually not possible to eliminate standing waves on the outside surface of the coaxial line and oscillator.

Two oscillators constructed in the laboratory to avoid this difficulty are shown in Fig. 19 and Fig. 20. The two-tube model in Fig. 19 uses a flexible parallel line feeder. A variable coupling unit in the foreground is connected to this feeder through

(*Continued on page* 180)

ELECTRONIC APPLICATIONS

A New Curriculum in E

Industrial electronic applications emphasized in new option for electrical engineering students. Courses in electronic control and measurement and in electrical implementation fit students for broad gauge design and engineering positions in rapidly expanding field

By T. S. GRAY and R. H. FRAZIER

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Massachusetts Institute of Technology
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Highlights of Engineering Course on Electronics

1. The Electronics Option, a new curriculum in electrical engineering, provides instruction in a field of electrical methods of measurement, control, and implementation not now covered by conventional power or communication curricula, but which to some extent overlaps the fields of both these older curricula.

2. The cultural, basic science, and main-stem engineering subjects are identical with the two curricula which the new option bridges, but the special professional subjects use illustrative material that is in the special field of electronics.

3. The Electronics Option culminates in two special subjects: (A) electronic control and measurement, which covers the more important functional methods whereby electronic devices are used in control and measurement applications, and (B) electrical implementation, in which the overall behavior of systems involving control and measurement devices are analyzed, largely by the method of electric-circuit analogy and models.

4. Laboratory work as well as analytical study is carried on in association with those special subjects in which commercial apparatus is utilized liberally, but always for the purpose of illustration of principles rather than the study of details of construction or performance.

DEVELOPMENTS in recent years show a slow but steady growth in the range of electrical engineering, a growth which lies squarely in neither of its traditional divisions, power and communications, yet overlaps both of them to some extent. The economic value of the power utilized by this growth is, in most instances, of minor importance to the user, and the communication of intelligence is usually not an objective. The new field has wider scope perhaps than either of the traditional divisions, for it covers electrical utilization in the home, office, plant, laboratory and farm, and in many modes of transportation.

Since in such utilization a marked trend at present is toward increased use of electronic equipment, the name electronic applications is used hereafter to describe the field. Actually the term *electronic* is too narrow, for the field includes electrical methods of measurement, control and implementation in all types of industry and engineering. It covers the full range of frequencies from direct current to radio frequencies, and the full range of power from the fraction of a microwatt available from a phototube or thermocouple to the hundreds of kilowatts used in induction heating. Instead of the problem of the alternator in power engineering, electronic applications has, for example, the problem of a vibra-

in Electrical Engineering

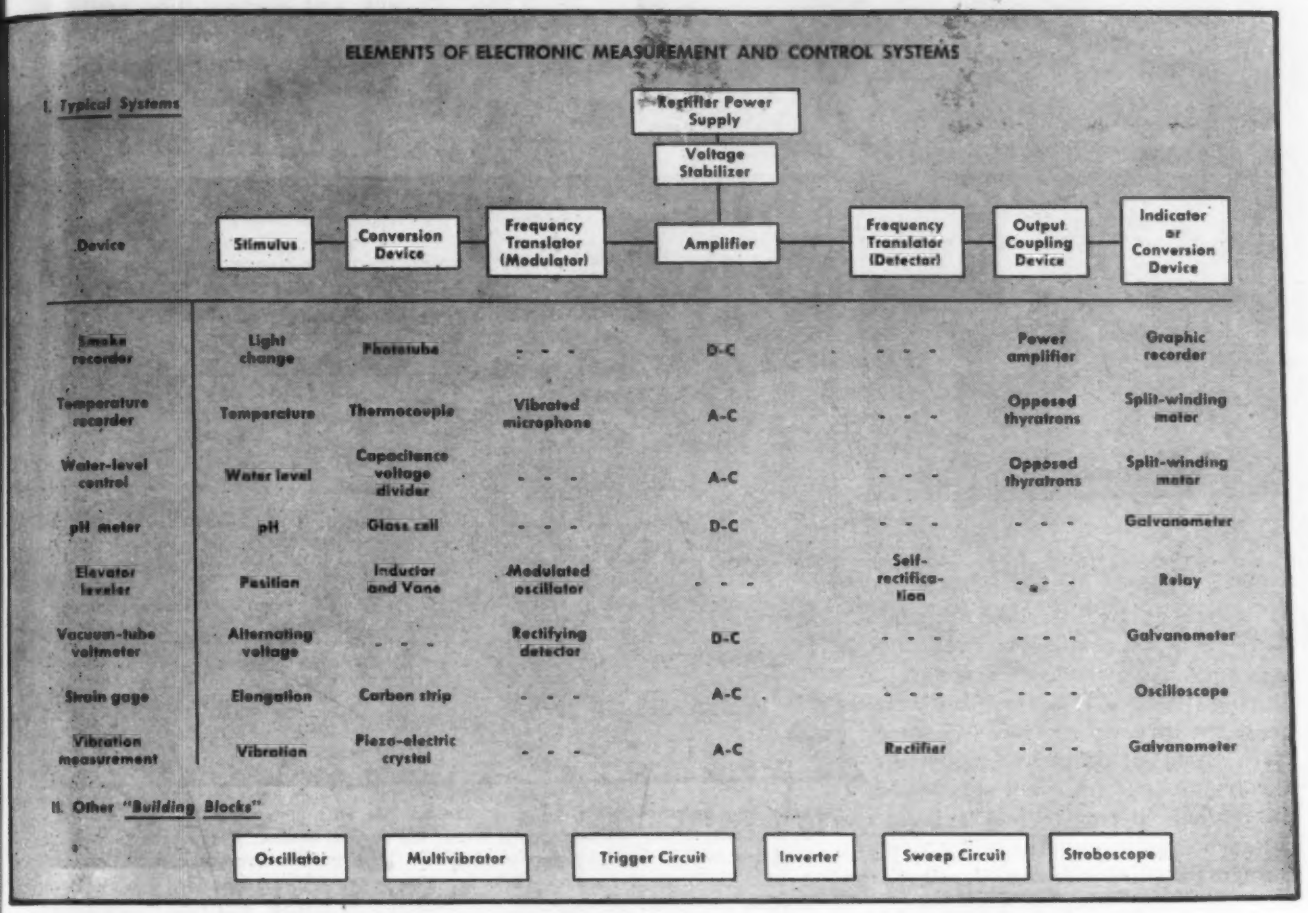

FIG. 1—Outline of some functional elements in a few typical industrial electronic applications

tion pick-up for measurement purposes. Instead of the use of frequency modulation in communication engineering, electronic applications has the use of frequency modulation in a control system. Many other similarities and contrasts, such as that of motors and relays, and that of radio transmitters and induction-furnace oscillators, can be cited.

Post-War Need for Engineers

The unprecedented war demand for engineers trained in electronics and the accompanying tremendous expansion of production facilities have accelerated the growth of the field to an extent that will only be fully realized after the war. Even before the war, most engineering schools had recognized the increasing importance of electronics and many have made a more or less prominent place for it in their curricula. Among these recent educational developments is a new curriculum at the Massachusetts Institute of Technology, a description of which follows.

This new curriculum is part of an expanded undergraduate electrical-engineering course of study requiring four academic years, which now has four options: power, illumination*, communications, and electronic applications. The curricula of these options are identical through the first two years, and have substantial portions in common in the third and fourth years. For present purpose of comparison, consideration of the power, communications, and electronic options seems adequate, since the electronics option straddles certain special elements of the power option and certain special elements of the communications option, but has little in common with the special elements of the illumination option.

During the first two or two and one-half years the three options have in their curricula basic work in general chemistry, general physics (mechanics, heat, electricity, optics), analytic geometry, differential and integral calculus and differential equations, engineering drawing and descriptive geometry, applied me-

* The illumination option has been discontinued for the duration of the war.

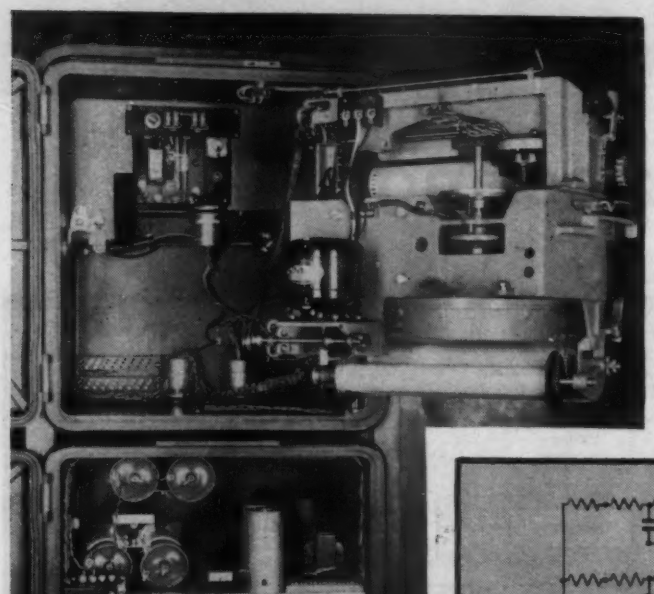

Fig. 2—This Leeds and Northrup recording potentiometer illustrates an important application of electronics to the field of industrial electronics

dynamics emphasizes the kinetic theory of gases, with applications to gaseous conduction, thermionic emission, photoelectric effect, electron optics, radioactivity, and nuclear structure; it includes no additional study of alternating-current machinery, but includes instead additional study of electric circuits, transformers, and electron-tube applications; that is, corrective networks, filters, and other coupling networks, vacuum-tube rectifiers, amplifiers, oscillators, modulators and demodulators,

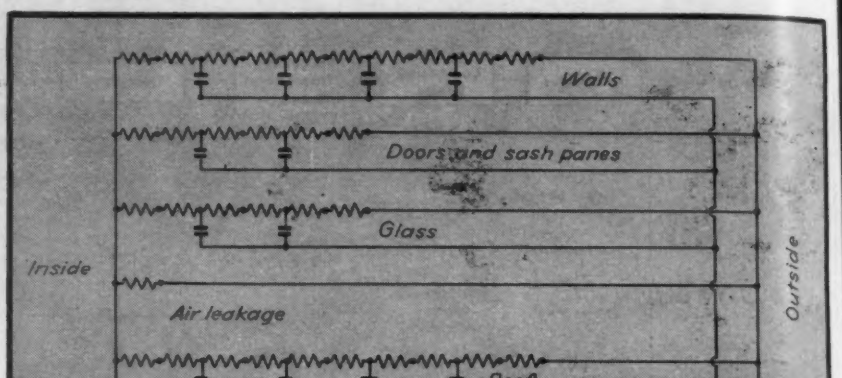

FIG. 3—Electric-circuit view of a house. The current source I_1 represents the heat supply to the house through ducts; the current source, I_2 represents the heat supplied in the cellar by thermal losses. These current sources can be realized by the use of high vacuum pentodes. The series R-C combinations beside these sources represent, respectively, the contents and interior structure of the upper floors and cellar. The voltage source, e, represents the outside temperature. This diagram is an example of the use of electrical methods for studying a wide variety of problems which originate in other fields

chanics (statics, kinematics, dynamics, strength of materials), English and history, economic principles, military science, and physical training. During the last two and one-half years the three options have the same main stem of electrical subjects: steady-state and transient analysis of direct- and alternating-current circuits; magnetic circuits and transformers; applied electronics; direct- and alternating-current machinery; and associated laboratory work with each of these subjects. A thread of subjects of a cultural nature, called general studies also continues through this period. These general studies may be selected by the students from many such subjects offered. Ordinarily, students are not permitted to make substitutions among the basic and main-stem studies. This summary of the common ground of the curricula of the three options serves as a background for pointing out their special elements, all of which are in the last two years.

The power option includes additional study of dynamics, with emphasis on application to rotating and reciprocating machinery of electromechanical construction; hydraulics, including hydraulic turbines and pumps, with emphasis upon flow of water through orifices, nozzles, weirs, pipes, and open channels; thermodynamics, with emphasis upon applications to steam engines and turbines, power-plant cycles, air compressors, and internal combustion engines; additional study of alternating-current machinery; and electric power transmission and distribution. All of these studies have associated with them appropriate laboratory work. Finally the option provides for certain elective subjects in the professional field, called professional electives, and a thesis, mentioned subsequently.

The communications option includes instead of the additional dynamics of the power option, the study of vibrations and sound; it includes no hydraulics; its study of thermo- photoelectric devices and associated laboratory work; transmission lines for communications purposes, electromagnetic radiation and propagation. This option also provides for professional electives and a thesis.

Scope of Electronics Option

The electronic-applications option includes the dynamics of the power option and the thermodynamics of the communications option; instead of the hydraulics of the power option, it includes study of fluid mechanics, which does not emphasize water as a medium, but treats more generally the physical properties of fluids, with application to various hydraulic apparatus; instead of additional study

(*Continued on page* 304)

Graphic Solution of Design Problems Involving SENSITIVE RELAYS

By R. T. FISHER

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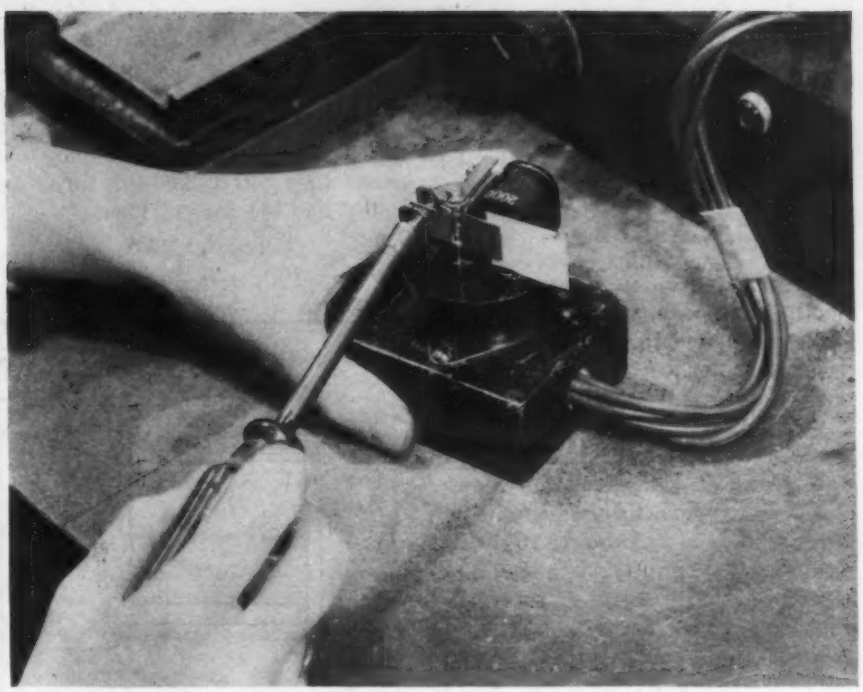

A method of presenting relay data which permits determination of performance under any static electrical condition without resort to experimentation. Proposed system of curves helps both users and designers of relays

THE WAR has greatly increased the demand for sensitive relays and has, at the same time, complicated the problem of design. Users and designers of such relays have frequently found it difficult to meet on common ground.

Attempts on the part of the user to state a relay problem in terms which would permit the designer to produce a satisfactory unit for a special application have not met with universal success. For reasons of military security it has often been considered desirable to hold back certain application details when preparing relay specifications. In other instances there has been a wide divergence of opinion between users and designers as to the completeness of data required.

The relay user may certainly be excused for not always realizing precisely what details a relay designer needs. On the other hand, the relay designer may similarly be excused for failing to request additional data concerning applications where he would have to be psychic even to know that specifications were incomplete. In many cases, however, the resulting dilemma has been resolved only after the production of a considerable number of unsatisfactory relays or, in the case of research projects, after much time has been wasted in blind alleys.

A method of presenting relay performance data in a form useful to users and to designers has been evolved which might go far to correct these difficulties. A complete description of the proposed graphical method of data presentation follows.

Fundamentally, a relay is a remotely controlled switch. As a switch, its purpose is to open and close contacts as dictated by the controlling electric circuit.

Most attributes of switch performance, other than matters controlled by choice of contact materials and arc suppression methods, can be directly related to motion and force. More specifically, with any given design of magnetically operated switch, performance is governed by contact pressure* on the one hand and contact separation on the other.

Fundamental Assumptions

This statement assumes static, or relatively static, electrical conditions. It considers closed contacts as electrical conductors and open contacts as electrical insulators. (Under some conditions, speed of break or make and frequency of operation are important factors in switch performance. These factors are not considered here but static requirements must be met in any case as a prerequisite to successful solution of any further problems that may arise.)

It is not difficult to present tabulated data indicating conservative minimum values of contact pressure

* As used, the term "contact pressure" does not involve the usual concept of unit area. It is used, rather than the term "contact force", to distinguish it from magnetic force, which does not involve physical contact.

and separation which, when obtained on a relay of given design, will yield satisfactory switch performance under different stated circumstances. This has not been done generally because, until now, no practical method of using such data intelligently has been devised. Although engineers could be told that they could expect good contact performance if they used so many grams of contact pressure and so many thousandths of an inch of separation, they could not easily be told what general conditions in the relay input circuit would yield these values.

System of Curves

The essence of the suggested method of presenting relay performance characteristics so that this tabulated data can be put to good use in design work is a system of curves.

The curves represent the space and force relationships that prevail in the relay at various input power levels and various adjustments. They are possible to draw only if an approximate assumption is made. This approximation consists in representing, by a single curve, the force present in the air gap at a given value of input power as the air gap is varied. The force is exactly proportional to the square of the flux density in the gap. The flux density is not, however, governed entirely by the coil power and the gap length, because of the effects of magnetic hysteresis in the iron.

The assumption is valid because, in modern sensitive relays, the iron materials used are highly permeable and have very small hysteresis loops. This means that the magnetic intensity left in the iron when power is removed from the coil is so small that it cannot send any appreciable flux across an air gap. Practically speaking, therefore, no serious error is introduced by the use of a single curve to represent force at a given value of coil power as the gap length is varied.

It is well to recognize at this point the importance of thinking in terms of coil power rather than coil current. This always seems wrong at first, in that the ampere turns in the coil are fundamentally what counts. However, on a given design of relay, although many different values of coil resistance may be offered, the physical dimensions of the coil are usually quite constant. And when certain physical dimensions are given, it is approximately true to state that a given power value will produce a given number of ampere turns irrespective of any change in coil resistance.

As one changes wire size to achieve more turns and resistance, the resistance varies approximately with the square of the turns. The following relationships then obtain:

Let r_1 and r_2 represent the resistances of two different coils with the same physical dimensions. Assume that coil 1 has 100 turns and coil 2 has 141 turns. Then

$$r_1/r_2 = 100^2/141^2 = \tfrac{1}{2}$$
$$2r_1 = r_2$$

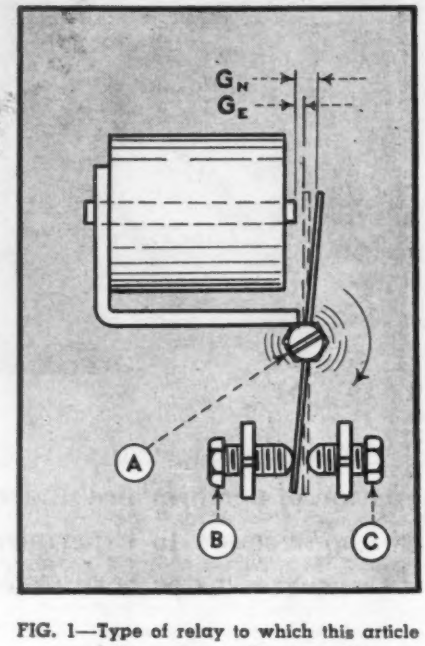

FIG. 1—Type of relay to which this article and the curves in Fig. 2 apply

Let $r_1=1$ ohm, $r_2=2$ ohms. Then, when the current is one ampere in coil 1, $I^2r = 1^2 \times 1 = 1$ watt dissipated in coil 1. Also, for 1 ampere in coil 1, there will be 100 ampere turns.

Coil 2 will dissipate one watt when $2I^2=1$ or $I^2=\frac{1}{2}$ and $I=\sqrt{2}/2$. For this current in coil 2, the ampere turns will be $\sqrt{2}/2 \times 141$, or 100 ampere turns just as before.

This relationship allows representation of the performance of any relay of a given design, of whatever coil resistance, by a single family of curves. An Ohm's law calculator or slide rule makes their use very convenient. A complete description of the curves and their use in the design of a relay like that shown in Fig. 1 follows.

Each curve in Fig. 2 shows, for one particular value of coil input power, the approximate magnetic force developed at the gap between armature and coil core as the length of the gap is varied.

Graphical Analysis of Performance

If the armature is pivoted exactly half-way between gap and contacts as it is in Fig. 1, then the contact pressure will always equal this magnetic force less the force of the restoring spring. If this subtraction yields a negative remainder, the spring force being greater, the pressure will be on the normally closed contact (B). The spring force is a torque, as is the magnetic force, and both must be measured at the same distance from the pivot.

In order for the method of using these curves to have general application among different relays a convention is necessary regarding the point at which forces are to be measured. It is suggested that this point be chosen as the contact position. If so, no consideration need be given to the relative position of the pivot. In cases where it is difficult to measure the force at the contacts, it can be measured at some other point and the values corrected to equivalents at the contacts.

It will be noted in Fig. 2 that each curve is marked with two different power values, for two different types of coil construction. The reason for this is that form-wound coils not having paper between layers of turns have a larger volume of copper and, therefore, effectively different and larger physical dimensions and more ampere turns per milliwatt.

The heavy lines and figures, superposed over the curves in Fig. 2 represent a typical relay operation cycle.

Let us assume that it refers to the relay shown in Fig. 1. Note that the armature motion allows the air gap at the coil core to vary from G_n to G_c. Two vertical lines are drawn in Fig. 2 at points which represent the lengths of G_c and G_n, measured from the origin along the horizontal axis. A horizontal line has been drawn from a point on the vertical axis which represents the spring force. (Note that in theory this line should not be horizontal but should slope downward by an amount depending on the force of the

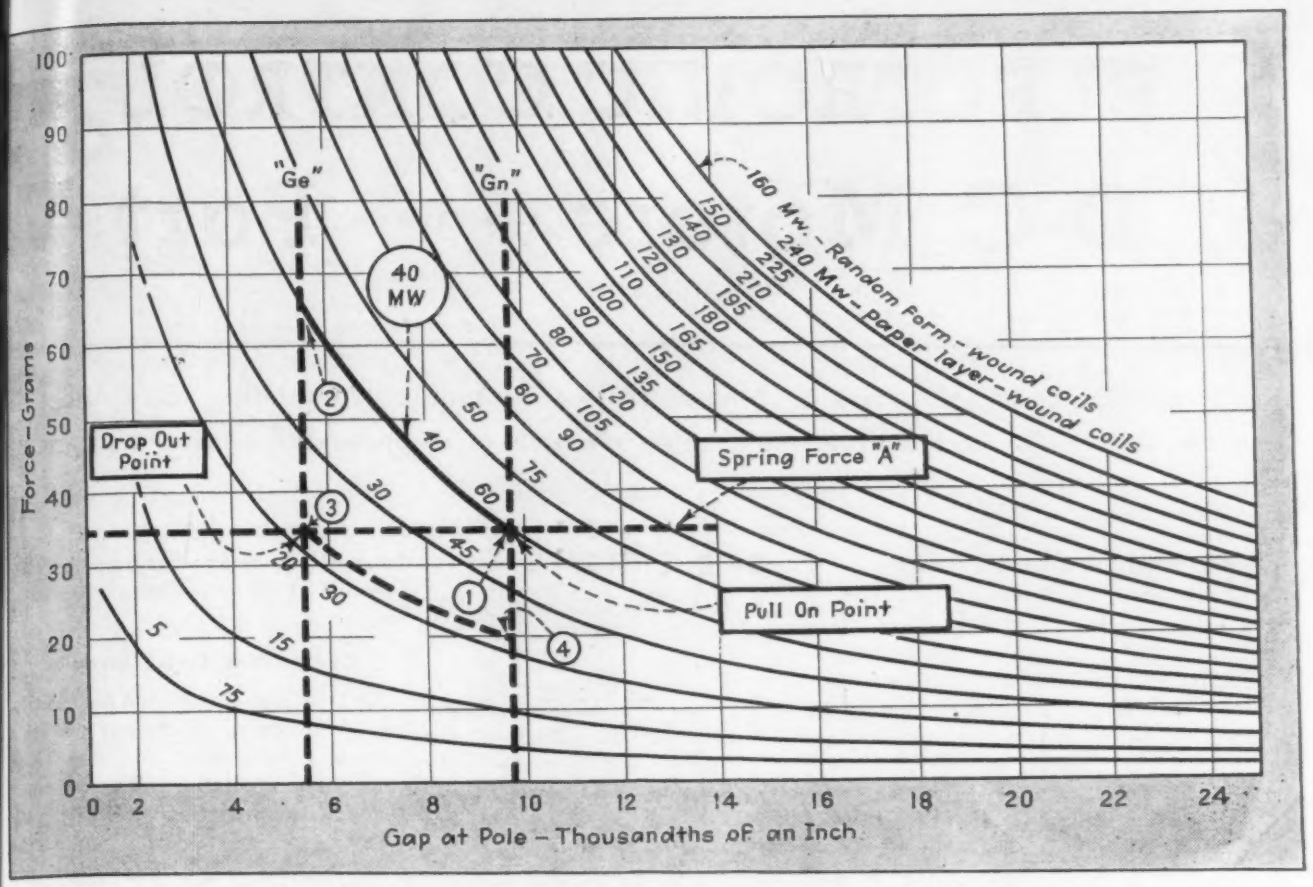

FIG. 2—Heavy lines superposed on this family of curves for a Sigma type 4 sensitive relay are used to analyze the relay operation cycle, as explained in the text

spring. This force is usually less than a gram over the range of operation and is therefore neglected.)

Before current is applied to the coil, the spring will hold the armature in the position G_n with a force of "A". As increasing current is applied to the coil, an increasing magnetic force opposes this spring force. When the coil power reaches a value of 40 milliwatts, the graph shows, that in this particular case the magnetic force will have exceeded the spring force by a small amount above point (1). The result is, of course, that the armature rotates to the other extreme of its travel (the relay pulls on) and the pole gap becomes equal to G_c.

With the gap at this value and the coil power still 40 milliwatts, the graph shows, at point (2), that the magnetic force exceeds the spring force by an amount equal to the distance from point (2) to point (3). This amount is, then, the contact pressure developed on the normally open contact (C in Fig. 1) when the relay has just pulled on.

Now, let the coil power be decreased. When it has dropped sufficiently low the magnetic force will have become slightly less than the spring force, the spring will restore the armature to its original position, and the relay will have "dropped out." The coil power value at which this occurs is indicated by point (3), which is a point on an interpolated curve yielding force "A" at a gap equal to G_c. The power value of this curve is estimated from its position with respect to given curves, and is the drop out value for the adjustment under consideration.

When the armature drops out, restoring the gap to the value G_n, the magnetic force will be determined by point (4), the intersection of the interpolated curve passing through point (3) with the vertical line at gap G_n. The contact pressure immediately after drop out will then be equal to the difference between the magnetic force given by point (4) and the spring force "A", shown at point (1). As the current decreases further toward zero, the contact pressure on the normally closed contact (B in Fig. 1) approaches the value of "A". The cycle has now been completed.

Practical Example

The curves may be used as follows:

1. From data supplied by the relay manufacturer regarding pressures and spacing necessary for good switch performance under various circumstances of electrical load and environment, coupled with an analysis of the particular problem at hand, limiting values of minimum air gap, contact spacing and pressure are determined.

2. A trial cycle is sketched in. The problem of where to start may seem confusing at first, but is really obvious after a little familiarity is gained.

If the problem is expected to tax the sensitivity of the relay, it will probably be advisable to use the

(*Continued on page* 310)

ELECTRONIC CONTROL of D-C Motors · · · · · Part V

Final installment of this series on tube-controlled d-c motors, completing the subject of regeneration by inverter action and treating methods of stopping and control equipment

By E. E. MOYER

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WHEN THE LOAD current during inversion in a thyratron circuit is a series of discontinuous pulses, with the anode current through each thyratron being a separate pulse that dies out before the next tube fires, there is no particular problem to inversion. In this instance, the current through the outgoing thyratron is extinguished because the direct voltage generated by the motor is less than the instantaneous values of the negative alternating voltage of the transformer and because the circuit inductance is insufficient to maintain the current flow against the then greater negative alternating potential. In this way, the net tube voltage ultimately becomes negative and current ceases. In Fig. 1, the current and voltage relations existing during inversion are compared with those for rectification. Diagrams E1 and F1 of Fig. 1 are intended to show the effect of an increase in motor emf upon the tendency of the circuit inductance to prolong current flow into the region where the negative alternating potential is greater than the direct potential of the motor. In F1 of Fig. 1 there is yet some margin of safety before the current will exist throughout the complete area and before conduction will be carried over into the region where the going-positive alternating potential will maintain current flow into the succeeding half cycle of rectification. Preventing conduction from continuing into the positive half cycle is one of the problems of inversion; holding the current off after it has been stopped is another.

Commutation During Inversion

In D of Fig. 2 is shown a condition of continuous armature current such as may readily exist under overload conditions when the inherent inductance of the armature circuit is sufficient to widen out the conducting period of each tube so that successive periods, in effect, overlap. That is, tube conduction is continuous throughout the interval when the negative value of alternating potential exceeds the d-c value, so that the difference of these voltages alone is insufficient to extinguish the tube current. Now, at the time when one tube should cease conduction, its current is not zero, yet the current of the incoming tube must start from zero; hence, the one tube must transfer to the other a certain amount of current. The circuit inductance opposes any abrupt changes in current so that the current through the outgoing tube must be forced to zero by firing the incoming tube as a rectifier at such a time as to cause an a-c short-circuit current to tend to flow around the local a-c circuit comprising the whole transformer winding and the two thyratrons, and to tend to flow in a reverse direction through the outgoing thyratron. This form of commutation may be thought of as a process whereby—for the brief interval when the two thyratrons are simultaneously conducting and the transformer is, in effect, short-circuited on its own leakage reactance—

For purposes of consistency, the symbols employed in this article are those commonly used in communication circuits.—Editor.

THIS SERIES OF ARTICLES ON ELECTRONIC CONTROL OF D-C MOTORS HAS INCLUDED:

PART I—Outline of general principles. May 1943 ELECTRONICS

PART II—Reference voltage and speed control methods. June 1943 ELECTRONICS

PART III—Extending speed range by electronic means of field weakening. July 1943 ELECTRONICS

PART IV—Starting, stabilizing, and reversing. Sept. 1943 ELECTRONICS

PART V—Regeneration by inverter action, and stopping. Oct. 1943 ELECTRONICS

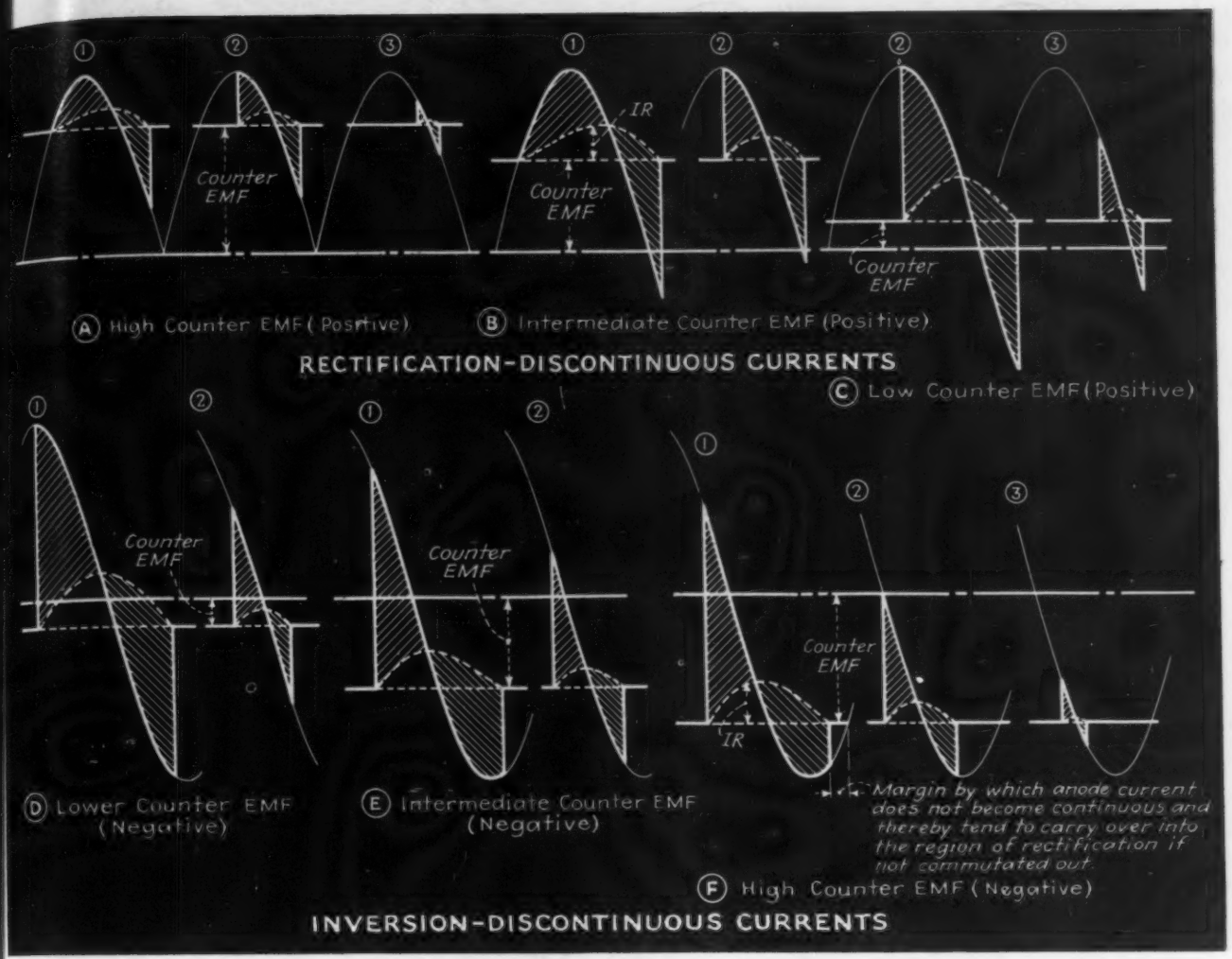

Counter EMF
IR
Counter EMF
Counter EMF
(A) High Counter EMF (Positive)
(B) Intermediate Counter EMF (Positive)
RECTIFICATION-DISCONTINUOUS CURRENTS
(C) Low Counter EMF (Positive)
Counter EMF
Counter EMF
Counter EMF
IR
(D) Lower Counter EMF (Negative)
(E) Intermediate Counter EMF (Negative)
Margin by which anode current does not become continuous and thereby tend to carry over into the region of rectification if not commutated out.
(F) High Counter EMF (Negative)
INVERSION-DISCONTINUOUS CURRENTS

FIG. 1—Effect of firing point and counter electromotive force on magnitude of anode circuit for rectification and inversion

the a-c short-circuit current is "riding backwards" on the normal load current which is keeping the outgoing tube conductive.

This commutating period is shown in diagram E of Fig. 2, where the counter voltage of the inverter is temporarily at zero and the difference in voltage between it and the motor emf is temporarily absorbed by the armature inductance and resistance. At the instant the circulating current and the load current are equal, the net tube current is zero-going-negative and the valve action of the tube prevents its current from reversing; thus, the current merely becomes zero where the negative grid must maintain it at zero by preventing firing until the correct firing point is again reached.

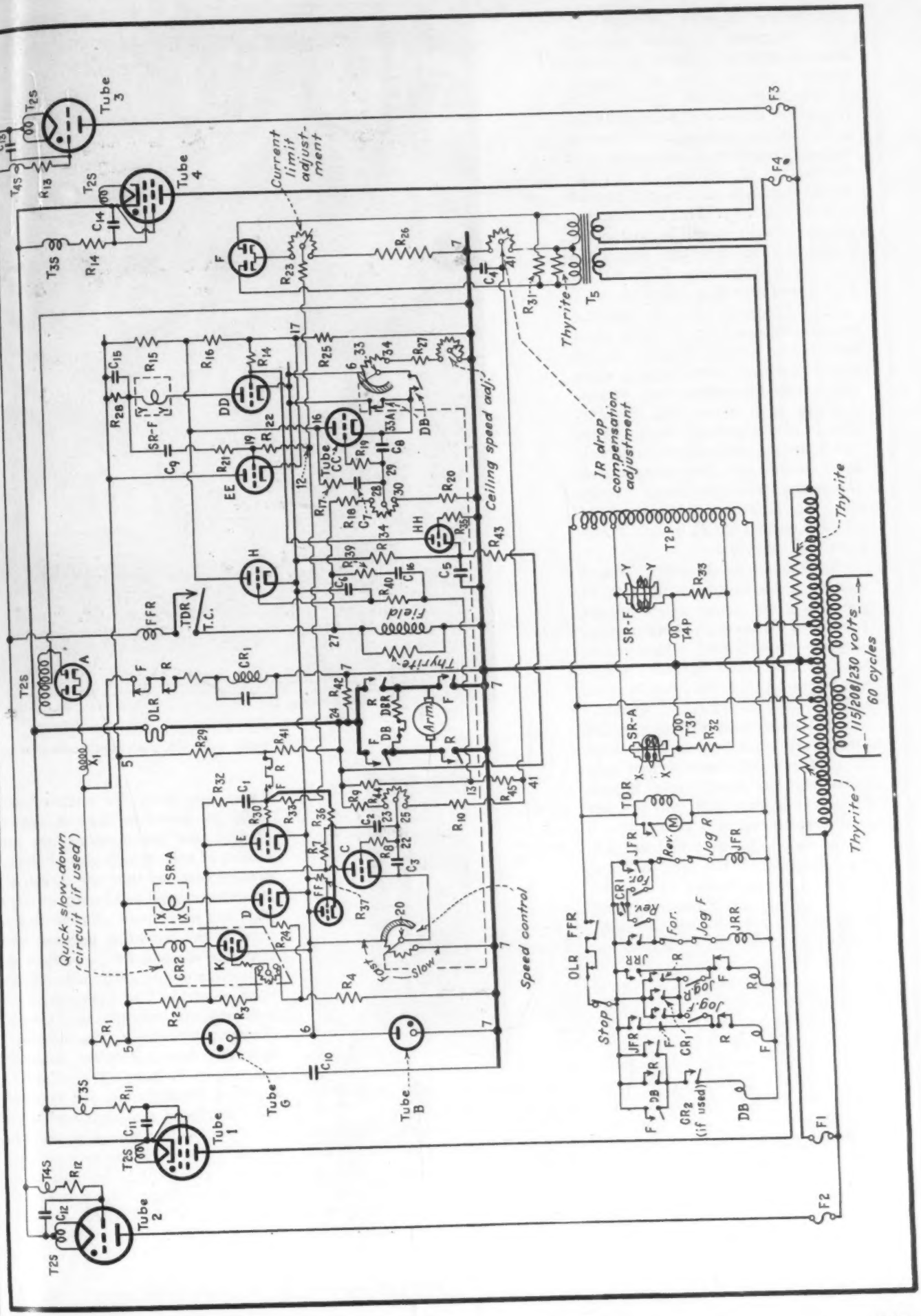
Firing Points in Inversion

The firing point of the incoming thyratron must be sufficiently ahead of the zero-going-negative point of the a-c wave so that the alternating voltage difference between the two tubes can cause an a-c short-circuit current of such magnitude (it is limited mainly by the leakage reactance of the anode transformer) that in the very few electrical degrees during which the armature current must be transferred from the one tube to the other, this commutating current will build up to a value equal and opposite to the armature current in the outgoing tube and will force the current to zero in this tube. Furthermore, the current must be forced to zero at a time when the net anode voltage on the outgoing tube will be negative and will stay negative long enough for the negative grid to regain control and prevent reconduction.

During rectification, as shown in A, B, and C of Fig. 2, there is no problem in keeping the current from re-establishing itself in the outgoing tube because its anode voltage is becoming increasingly negative. But, during inversion, the anode voltage is becoming decreasingly negative and actually tends ultimately to become positive so that a region is reached where, due to a condition of positive anode voltage, a negative grid potential is necessary to prevent conduction.

The firing point of the incoming tube (diagram F of Fig. 2) has been advanced so far toward the rectifier zone that, for an appreciable time after commutation, the anode voltage of the outgoing tube is negative to such an extent that there is ample time for the negative grid to regain control. But, it should be evident that in a region somewhere near, and ahead of, the crossing point of the a-c waves this helpful negative anode voltage does not exist sufficiently long to allow the tube to deionize and its grid to regain control, and hence, inversion fails.

For successful inversion of con-


Tube 3
Tube 4
Tube 1
Tube 2
Current limit adjustment
Thyrite
IR drop compensation adjustment
Ceiling speed adj.
Field
Armature
Speed control
Quick slow-down circuit (if used)
Fast
Slow
Stop
Jog R
Jog F
Rev.
For.
JFR
JRR
JR
JF
DB
OLR
FFR
TDR
T.C.
SR-A
SR-F
115/208/230 volts
60 cycles

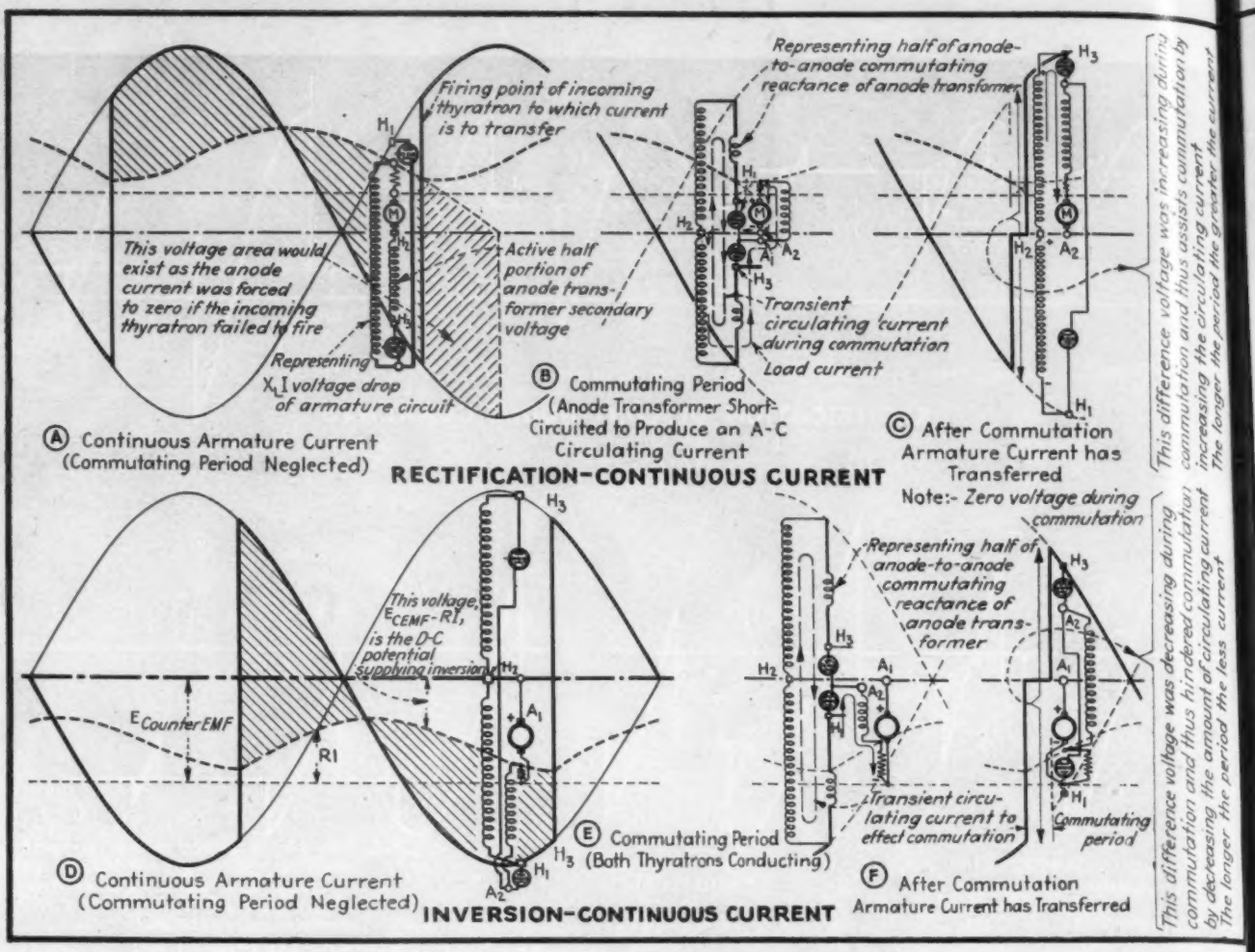

Representing half of anode-to-anode commutating reactance of anode transformer
Firing point of incoming thyratron to which current is to transfer
This voltage area would exist as the anode current was forced to zero if the incoming thyratron failed to fire
Active half portion of anode transformer secondary voltage
Representing $X_L I$ voltage drop of armature circuit
Transient circulating current during commutation
Load current
This difference voltage was increasing during commutation and thus assists commutation by increasing the circulating current. The longer the period the greater the current
A Continuous Armature Current (Commutating Period Neglected)
B Commutating Period (Anode Transformer Short-Circuited to Produce an A-C Circulating Current
C After Commutation Armature Current has Transferred
RECTIFICATION—CONTINUOUS CURRENT
Note:- Zero voltage during commutation
This voltage, $E_{CEMF}-RI$, is the D-C potential supplying inversion
$E_{Counter\ EMF}$
RI
Representing half of anode-to-anode commutating reactance of anode transformer
Transient circulating current to effect commutation
Commutating period
This difference voltage was decreasing during commutation and thus hindered commutation by decreasing the amount of circulating current. The longer the period the less current
D Continuous Armature Current (Commutating Period Neglected)
E Commutating Period (H_3 (Both Thyratrons Conducting)
F After Commutation Armature Current has Transferred
INVERSION—CONTINUOUS CURRENT

FIG. 2—Comparison of commutation during rectification and inversion

tinuous current, the firing point of the incoming thyratron will have to be advanced toward the region of rectification if the load current, and therefore the current to be commutated, is increased. Phase advancing toward the rectifier region has the effect of reducing the counter voltage of inverter action. This counter voltage opposes the armature generated voltage to limit the very armature current which is being commutated. Hence, there is a definite relation between that value of armature current which is to be commutated, the counter voltage of the inverter corresponding to successful commutation, and the generated voltage of the motor which is the source of current.

Armature Current Limit and Control During Inversion

During the inversion period, the armature current corresponding to a given circuit resistance is determined by a net voltage which is the difference between the generated voltage of the motor and the average negative counter voltage of the inverter. Thus, two voltages govern the magnitude of armature current during the inversion period: (1) the generated voltage of the motor; (2) the counter voltage of the inverter, if it is assumed that the circuit impedance, the motor speed, or the alternating anode voltage are not readily adjustable. The generated voltage of the motor is a function of motor speed and field excitation. The counter voltage of the inverter is determined by the firing point of the armature thyratrons.

Under certain limited conditions of reversing operation, the armature preconditioning control and the armature current-limit control will also function to maintain a constant current-limit value of armature current during the inversion period of regenerative deceleration. This applies particularly to motors having good commutating ability, operated with a very limited degree of field weakening, and driving a low-inertia load.

It should be noted that, while the armature preconditioning circuit tends to control the thyratron output to a relatively low voltage as a rectifier under open-circuit armature conditions, the firing point corresponding to this low direct potential happens to be in the region of correct firing for successful inversion of 100–150 percent armature current at approximately rated armature voltage. However, this particular operating condition is much more critical with polyphase circuits than with single phase.

Motor Reversing During Inversion

Since armature current, inverter counter voltage, and motor voltage have to be co-ordinated for successful inversion, it is essential that the control shown in Fig. 3, used to rapidly reverse a motor coupled to a high-inertia load and operating from a field-weakened condition, should

FIG. 3—Elementary circuit diagram of complete reversing drive for Thy-mo-trol control

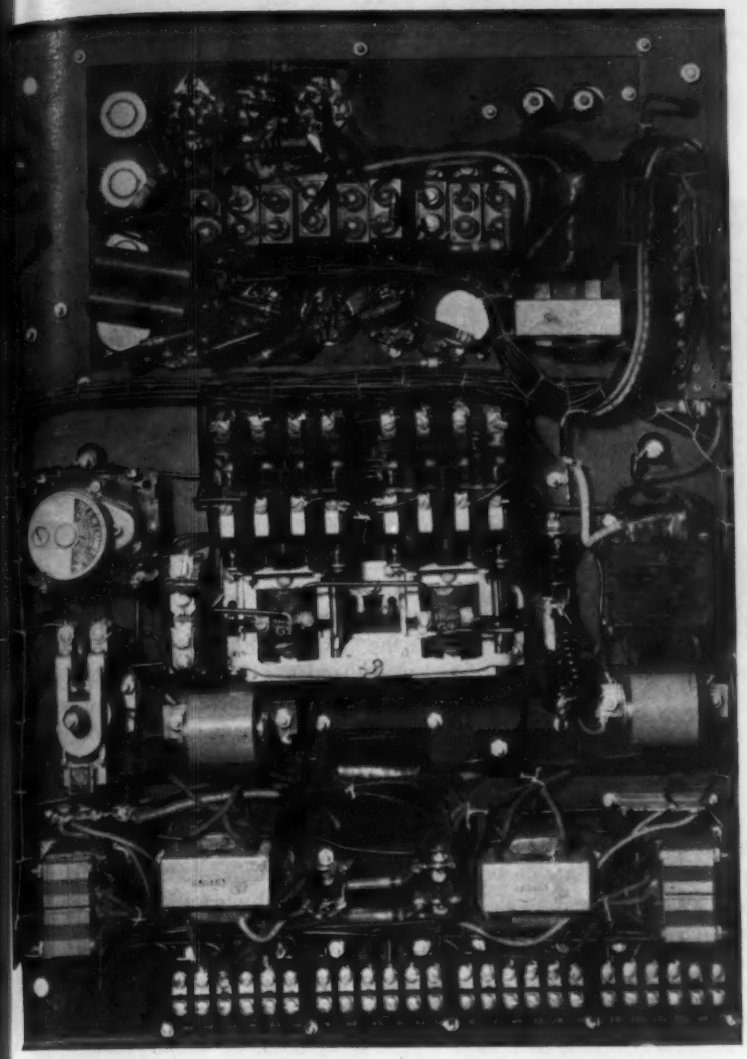


FIG. 5—Interior of reversing panel for armature and field control

conditioning respond rapidly and reach its preset operating level as quickly as possible because this action presets the initial firing point of the thyratrons as inverters to correspond to the armature voltage which is being regulated by the negative voltage-limiting tube (HH).

Auxiliary relay CR_1 is necessary to give added time delay to the reversing operation of the reversing contactors while the preconditioning circuits establish themselves. Only two cycles are required for the reversing contactors to operate whereas four to six cycles are required for the armature preconditioning circuit.

Transition from Deceleration to Acceleration

After the reversing contactors have operated, the open-circuit armature voltage preconditioning circuit will have been disconnected from tube E. This will allow tube E to perform its normal function of regulating the firing point of the armature thyratrons to maintain a pre-selected current-limit value of armature current. Then, as deceleration begins and after full-field is reached, the motor voltage decreases and the armature current reduces. This allows tube E to ease up on its restraint of tube D, which phase-advances the firing point toward the rectifier zone and thus decreases the inverter counter voltage.

When the point is reached at which the inverter voltage is zero, further phase advancing will cause the tubes to begin to act as rectifiers whose output voltage increases as the firing point continues to be advanced toward the beginning of the positive half cycle of anode voltage. The changeover from inversion to rectification reverses the polarity of the tube circuit so that now, acting as a rectifier, the cathode terminal of the tubes is positive in the sense of being a generator and tends to force a current flow against the armature potential. The motor potential will be required to reverse to counter the rectifier voltage, hence the direction of rotation of the motor must reverse to generate this reversed potential. The motor then accelerates in this opposite direction of rotation, under conditions of armature current-limit control, until preset speed is reached.

Regenerative Braking to a Stop

The reversing circuits may also be used to provide a fast and smooth stopping sequence for the motor. All that it necessary is to provide two more relays in the relaying system which will signal for zero speed in

(*Continued on page* 312)

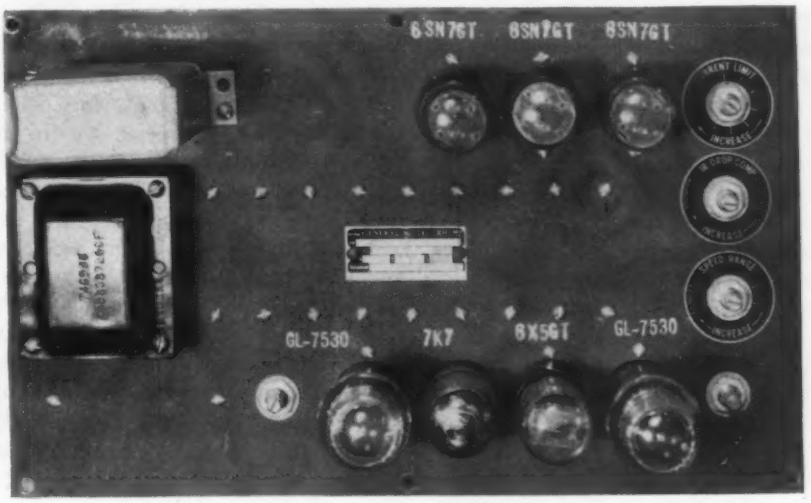


FIG. 6—Thy-mo-trol tube control panel, for d-c motor control. The panel is approximately 8 in. high, 14 in. wide and 6 in. deep, and weighs 10 lb

perform the following functions:

(1) Regulate the initial and subsequent armature voltage of the motor at a preset value, say approximately rated voltage, by control of the rate of increase of field excitation as a function of negative armature voltage (negative in the sense that the voltage of rectification and forward rotation is positive with respect to control bus 7). This assures that the motor voltage will be within the range of counter voltage which the inverter will develop. Tube HH in Fig. 3 performs this function.

(2) Precondition the inverter counter voltage to match the regulated motor voltage. This limits the initial armature current to a value which may be commutated successfully by both motor and inverter. This is also a level of current from which the normal armature current-limit circuit can take over control. The normal preconditioning circuit, plus the additional refinement of tube FF and relay CR_1 in Fig. 3 perform this function.

(3) Reduce the inverter counter voltage by grid phase control to match the decreasing motor voltage (due to a decrease in speed accompanying deceleration). This maintains approximately constant armature current throughout deceleration and on into the region of acceleration in the reverse direction. The normal armature current-limit control performs this function by phase controlling the firing point of the thyratrons toward and into the region of rectification.

The extra refinement of tube HH is necessitated by the fact that too rapid field strengthening at a high-speed condition could raise the emf of the motor faster than a high-inertia load would allow the speed to decrease to reduce this emf. That is, during the initial period of deceleration when tube EE is calling for full field in response to its armature current-limit signal the armature voltage would increase to levels beyond which inverter commutation would be possible. After reversal of the armature connections and prior to, and during, the inversion period, the armature voltage is negative with respect to the negative control bus, point 7. Tube HH receives a signal which is part of this then-negative armature voltage, compares this signal with the standard voltage of tube B, amplifies the difference, and operates on tube DD so that it regulates the field excitation to maintain a preset armature voltage.

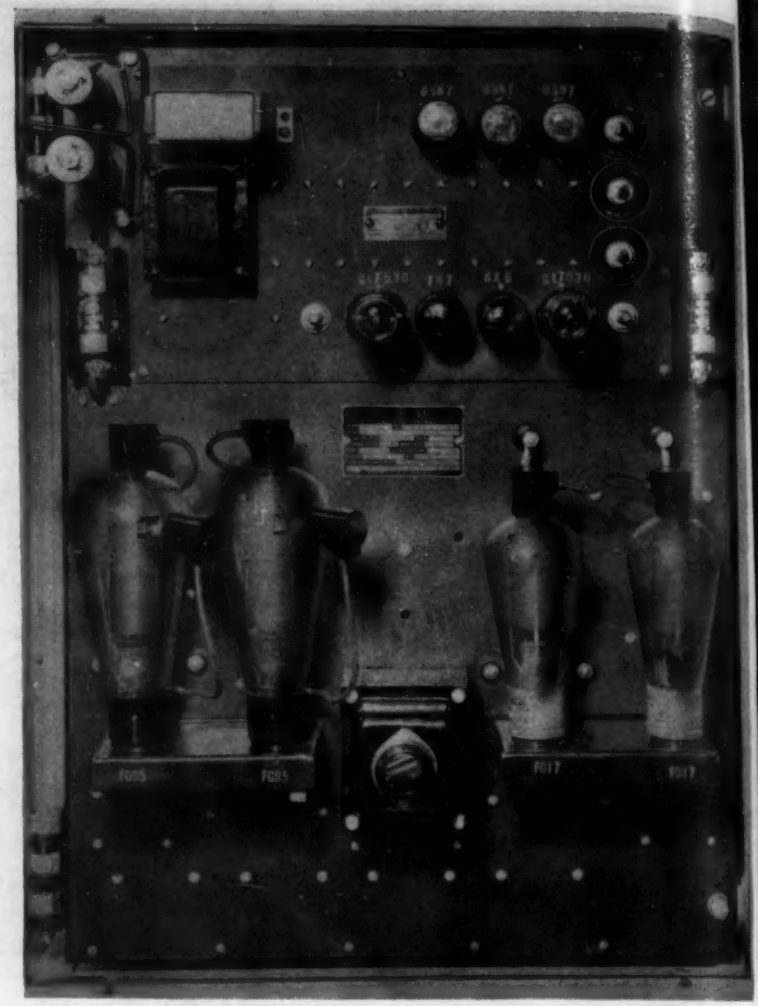
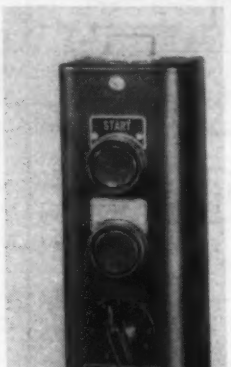


FIG. 4—Control panel for tube-controlled motor unit, with push-button control at left



Tube FF serves to precondition the armature current-limit pre-conditioning circuit by anchoring the junction of resistors R_{30} and R_{33} a few volts negative with respect to control bus, 6. That is, the potential of junction R_{30}—R_{33} can be increased positively from this anchoring position but cannot fall below it. These few volts are sufficient normally to maintain tube E nonconducting and yet maintain the grid circuit of tube E very close to its operating level so that the direct-voltage-proportional-to-armature-current does not have to be allowed time to develop the potential between junction R_{30}—R_{33} and bus 7 against the opposition of the antihunting circuit of R_{32} and C_1. The response of the current-limit circuit is therefore made much faster by the absence of this time delay. Another important function of the tube FF is to provide rapid preconditioning for reversals from low speed and light load where the speed is just about at the level at which the preconditioning circuit would, itself, want to regulate armature voltage. Hence the voltage difference available to effect preconditioning is limited and without tube FF more time would have been required to alter the potential across C_1. It is important to have this pre-

CRYSTAL HO

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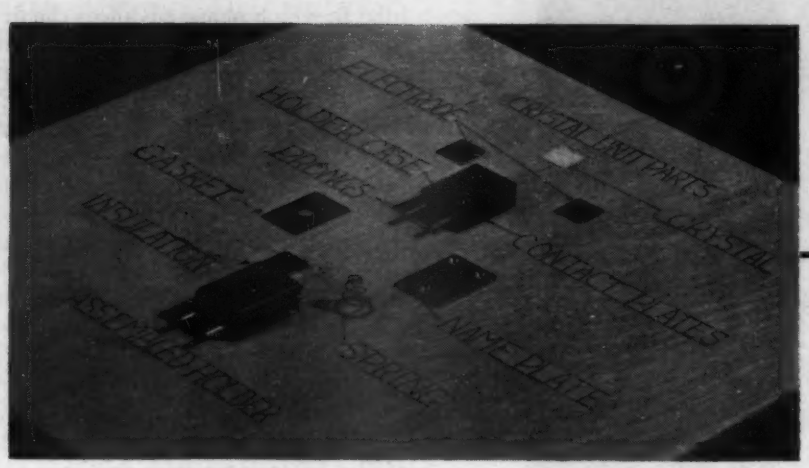


FIG. 1—Crystal holder type in cost common use

IN ORDER to make a quartz crystal oscillate at a radio frequency, it must be placed in a radio-frequency field. This is accomplished by placing the crystal between two metal electrodes connected to a source of radio-frequency potential.

An assembly consisting of electrodes, terminals or pins used to connect these electrodes to an oscillator circuit, a housing supporting electrodes and pins, a protective covering, and accessory parts is called a crystal "holder" or "mounting." Such a holder serves the combined purpose of incorporating the crystal mechanically into an electronic device and electrically into the circuit. A holder, with a crystal in place, is known as a crystal "unit".

A crystal mounting must be so designed that it permits free vibration of the crystal and also affords adequate protection against dirt and moisture. Care in holder design and manufacture is essential since good crystals, improperly mounted, prove entirely worthless. The type of crystal mounting used is determined by the mode in which the crystal vibrates[1], with modifications for different frequency groupings and specific uses.

General Considerations

The most common type of holder, pictured in Fig. 1, is usually made of some nonconducting plastic, although metal can be used in conjunction with proper insulation. The electrodes are made of pure nickel, duralumin, monel metal, German silver, or stainless steel. The contact plates are usually brass or silver-coated brass. The name plates and prongs are ordinarily made of nickel-plated brass. The spring may be copper or steel. The gasket is generally cork, neoprene, or rubber. The insulation is Bakelite, Isolantite or comparable material.

No matter what type of holder is used, there are several requirements which it must fulfill:

(A) The material used for the holder case and insulation must have reasonably low losses at the frequencies involved and must be physically stable. Any material which contains gases or liquids which are freed when heating occurs in service is not satisfactory. The material must not be too brittle, since external chipping affects the outward appearance of the holder and internal chipping affects the electrical characteristics of the crystal unit.

(B) The electrodes, pins, and contact plates or points must be made of a material which will not readily oxidize or corrode, since either greatly affects the working efficiency of the crystal.

(C) All material used in constructing the holder, such as the flux and solder used in soldering pins and other connections, as well as steel wool used for cleaning, must be completely removed. Recently, these have given considerable trouble to crystal manufacturers. Because some of these materials not visible upon first inspection were freed during the final testing of the crystals (temperature and shake tests) many crystals were made unworkable and had to be rejected. Flux chemically affects both electrodes and contact plates. Rosin and steel wool collect between the crystal and electrodes, preventing free oscillation of the crystal.

(D) The electrode surfaces must be perfectly parallel and free from oil. The latter consideration is very important since oil impairs the activity of the crystal.

(E) The entire assembly must be moisture-proof and free from dirt and dust.

(F) The holder must provide for free vibration of the crystal and at the same time support the crystal with sufficient rigidity so that mechanical shock will not change the characteristics of the crystal.

Although most companies have developed their own particular styles of holders and are constantly modifying them, holders may be grouped into the following general classes: (1) pressure mountings, (2) clamp mountings, (3) air-gap mountings, (4) combined pressure and air-gap mountings, (5) wire-supported crystal mountings, (6) mechanically or hermetically sealed mountings, (7) temperature-controlled or temperature-protected mountings and (8) multiple-type mountings. Most of

HOLDER Design

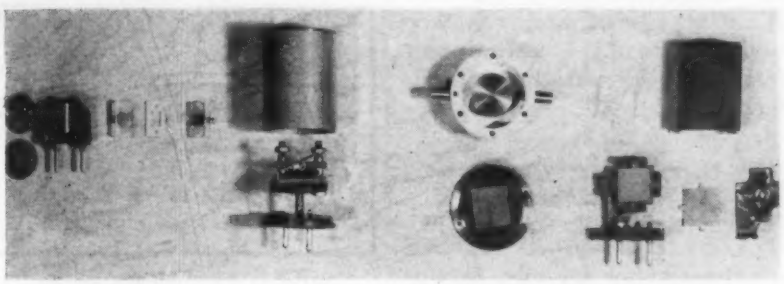
iezoelectric quartz plates used for frequency control in various types of electronic equipent must be incorporated in mountings which permit them to be readily and properly serted, physically and electrically, within such gear. Eight varieties of mountings are described here, each of them having distinct advantages for certain applications

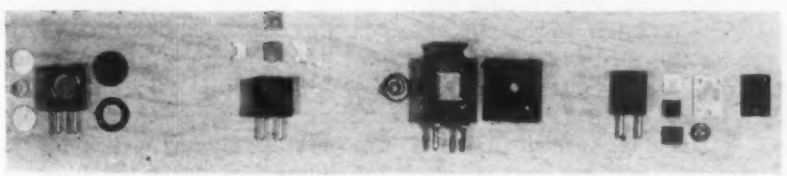
ese types are pictured in Fig. 2.

Pressure Types

In the pressure type holder shown Fig. 3, the electrodes are held in timate contact with the crystal by eans of a spring. This type of lder is particularly useful in aplications where the mounting is subct to severe external vibration or hock, since the crystal is held rigidly place. It can also be operated in any physical position without a change in frequency.

It has been found that there are optimum spring pressures for certain frequency ranges. Thus, where holders are to be used with different crystals covering a wide range of frequencies, variable spring pressure is frequently provided. This is done by placing the spring on a micrometer screw, so that by tightening the screw the spring pressure is increased. Where crystals having closely related frequencies are being manufactured, the best average pressure is predetermined for each frequency group and springs providing this pressure are used during production. Very little spring adjustment is necessary for each individual crystal in this case.





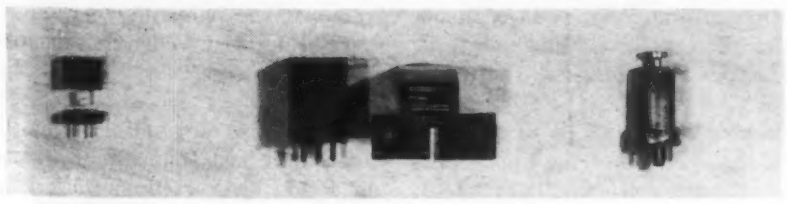


FIG. 2—Mountings of various types discussed in the text

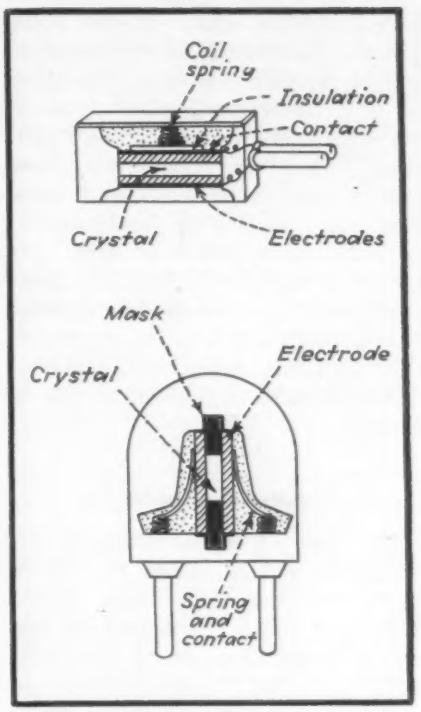


FIG. 3—Typical pressure type holders

Pressure type holders are used for "thickness" oscillators[1] operating between 1,800 and 30,000 kc. In holders designed to operate at low frequencies within this range the electrodes are usually perfectly flat and are approximately the same size as the crystal. In holders designed for use at higher frequencies within this range the size of the upper electrode is generally decreased to reduce the inter-electrode capacity.

Some companies use a disc as the upper electrode, while others recess a portion of the surface of a rectangular upper electrode, leaving a raised disc in the center and raised feet on the corners. See Fig. 4.

Clamp Types

The clamp type holder is a modification of the pressure type. Quartz crystals do not show equal vibration over their entire surfaces; that is, there are points of maximum vibration called antinodes, and points of minimum vibration called nodes.[1] The theory of the clamp type holder is to clamp the crystal between very small clamp-member areas at the nodal points. Electrodes of the metallic-coated type are used in such holders. A thin metal coating of silver or aluminum is evaporated or "sputtered"[2] onto the quartz crystal faces and is used in place of solid metal electrodes. The clamp then holds the crystal in place and at the same time makes contact with the electrode coatings. A good clamp holder must have small contact point areas, accurate alignment of points, and adequate pressure to hold the crystal in place.

Knife-Edge Holder

One type of clamp holder is the knife-edge holder shown in Fig. 5. There are four knife edges whose dimension along the length of the crystal is small and whose dimension along the width is just large enough to insure a rigid clamp. The nodal point of a longitudinally-vibrating crystal represents a straight line and thus we may use a knife edge instead of a single point.

Clamp Holders for Bar-Type Crystals

This type of holder is used for bar type crystals vibrating longitudinally or flexually[1] and covering the range from 15 to 280 kc. Extreme crystal activity is obtained with this type of holder. The frequency at which the crystal oscillates is less influenced by the characteristics of the holder than with most other types. Also, since the electrodes are formed directly on the crystal, the latter never need cleaning.

The clamp type is also being used for crystals vibrating as thickness oscillators. In this application, the crystal is clamped at the corners, which are the nodal points. Electrodes are plated directly on the quartz. The crystal surfaces are left unplated for short distances on opposite sides, at opposite ends, as shown in Fig. 6. This permits use of a simple combination clamp and contact assembly.

Air-Gap Types

In the air-gap type holder, there is an air-gap between the crystal and one or both of the electrodes. For operation lower in frequency than 1,800 kc, thickness oscillators of convenient size do not work properly when clamped, owing to the abnormal ratio of thickness to length. Such a crystal is conventionally mounted with a slight clearance between the upper crystal face and the upper electrode. Thus the crystal vibrations are not damped by the pressure of the upper plate. A further advantage of a spaced electrode is that the intensity of the electrostatic field across the crystal is reduced due to the use of what is effectively a series condenser in the crystal circuit. This reduced field helps to prevent breakage of the crystal due to dielectric failure of the quartz.

This class of holder can be further subdivided into (a) fixed air-gap holders and (b) variable air-gap holders

Fixed Air-Gap Types

The fixed air-gap type is not widely used except in connection with low-frequency filter crystals. In any type of air-gap mounting it is particularly essential to have the electrodes quite parallel. If this not the case the electric field will be unevenly distributed, tending to strain the crystal. In mounting electrode plates a fixed distance away from the crystal, a plastic mask or quartz spacers are frequently used. These hold the electrode a fixed distance away from the crystal and prevent lateral motion of the crystal at the same time. This type of holder is shown in Fig. 7.

When using a spaced upper electrode, the position of the upper electrode is quite critical. This critical position is a function of the radio frequency involved and the frequency of supersonic vibrations set up in the air of the gap by oscillation of the crystal. The activity of the crystal diminishes when the magnitude of the gap is a multiple of half the wave length of supersonic sound generated at the particular crystal frequency employed. When this condition exists, compressional waves leaving the crystal face encounter compressional waves rebounding from the electrode in such phase that a damping action is exerted on the crystal. The condition described is not serious at low frequencies since the distance between damping points is

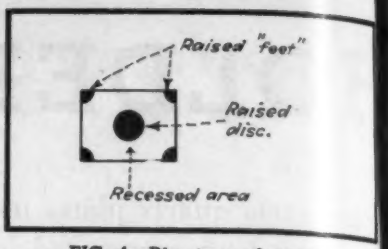


FIG. 4—Disc type electrode

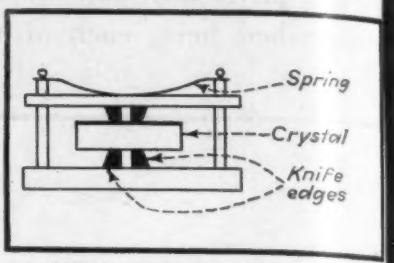


FIG. 5—Knife-edge holder

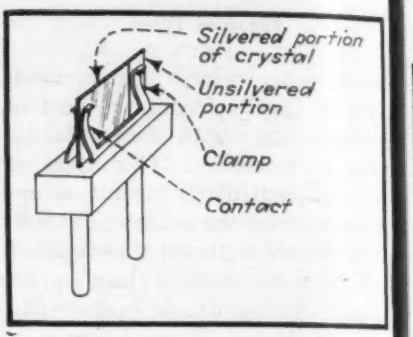


FIG. 6—Clamp type holder

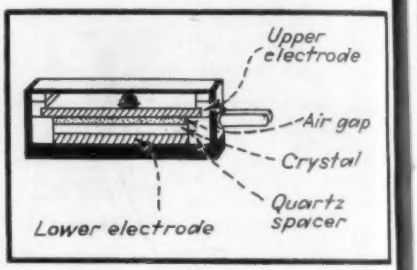


FIG. 7—Fixed air-gap holder

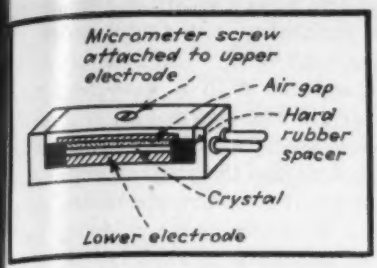


FIG. 8—Variable air-gap holder

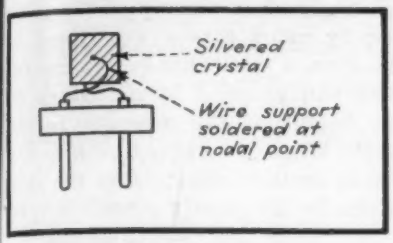


FIG. 9—Wire-supported crystal

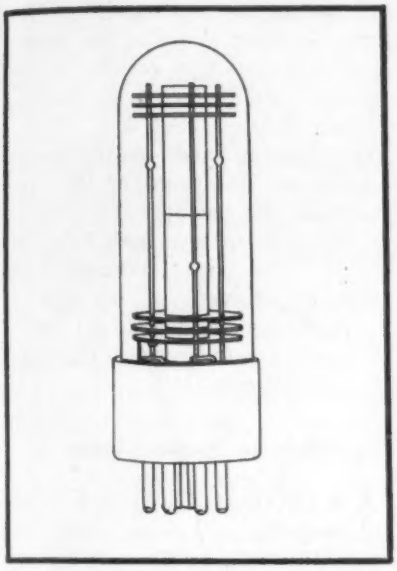


FIG. 10—Hermetically-sealed crystal holder

fairly large, but at high frequencies it becomes a factor.

Variable Air-Gap Types

In the adjustable or variable air-gap type of holder shown in Fig. 8, one electrode is fixed and the other is movable in a direction perpendicular to the major faces of the crystal. This is usually accomplished by permitting the crystal to rest on the lower electrode and attaching the upper electrode to a movable screw. The frequency can be varied over a relatively narrow range by changing the air gap. With a typical 5-Mc crystal the adjustment varies the frequency from 2 to 6 kc.

Reducing the air gap lowers the frequency and increasing it raises the frequency. Of course, this holds true only within certain limits. The air gap can be narrowed or enlarged only to a certain point without seriously reducing the activity of the crystal.

Frequency Range

The maximum frequency adjustment for this type of holder varies with the frequency of the crystal and also with the circuit. Frequency adjustment is particularly useful where the crystal must be maintained at an exact frequency or where the crystal has been ground for use in one type of circuit and is then used in another. This type of holder may conveniently be used to shift the frequency of transmission slightly to eliminate interference. Variable air-gap holders have been commonly ground for frequencies between 100 and 5,000 kc. Some companies manufacture such types that operate as high as 11,000 kc.

Pressure Air-Gap Types

The most common type of holder in use today is the combined pressure air-gap type of holder shown in Fig. 1.

As pointed out previously, a quartz crystal does not vibrate uniformly over its entire surface; that is, there are points of maximum and minimum vibration. In a crystal employing a BT or AT cut, vibrating in a thickness shear, the nodal points are at the corners of the crystal and these are small in area with respect to the surface area. Thus it is possible to clamp the crystal at its corners without impeding its vibration. In this type of holder the electrodes are recessed in the center by adding feet to the corners or stamping a recessed circular center into them.

Circular Pressure Air-Gap Types

One type of electrode is circular with a raised rim. Here the crystal corners are clamped by the rim. In this type of holder the crystal is held firmly in place by the tension of some type of spring. The recessed electrodes furnish the air gap, which is adjusted in manufacture. This type of holder lends itself particularly well to thickness oscillators operating between 1,500 and 9,000 kc. Its particular advantages include ease of manufacture, greater stability and improved performance. Variable air-gap holders are now made in the same design. A ring or frame is used to apply pressure to the corners of the crystal, and the upper electrode is adjustable. The frequency adjustment on such crystals is quite small, however.

Wire-Supported Types

Another type of mounting similar in principle to the pressure type mounting is the wire-supported crystal. See Fig. 9. This type of mounting has been found satisfactory for crystals having CT and DT cuts, which vibrate in a face shear. These have a single nodal point in the center of the face.

The crystals are silver-plated and are supported by wires soldered at their nodal points. The supporting wires also serve as a means of making electrical connections to the electrode coatings on the surfaces. After the supporting wires are attached to the crystal they remain in that position throughout the rest of the manufacturing process. The supporting wires provide a spring mounting even during production, protecting the crystal from shocks. After the wire has been soldered to the crystal, the unit is free from variation in performance due to slight changes in position and changes in contact resistance which prevail in pressure type holders.

Such a crystal unit is difficult to manufacture. The adjustment operations are, however, quite easy and the crystal case is very inexpensive. This type of holder is now, in some instances, being used in place of the knife-edge type and pressure type for low-frequency, bar-type crystals.

Sealed Types

Where crystals have to be absolutely dust-proof and moisture-proof, they are sealed either mechanically or hermetically. Mechanical sealing is generally accomplished with a flexible rubber or cork gasket and a rapid, hard-drying cement such as glyptol. All screws and nuts are covered with the glyptol and the

holder is baked. Then the holder is usually tested under water.

Hermetic sealing is usually accomplished by soldering or electrically welding a metal cover and base together to form a case closely resembling a metal tube, using Fernico wire and fused-glass lead-ins. When crystals are sealed in glass, the procedure of mounting a crystal unit on a stem and sealing it is much the same as in the manufacture of a glass radio tube. See Fig. 10. Oxygen gas flames are generally used for sealing, since they are sharp-pointed and have a high temperature. After the glass tubes are sealed they have to be annealed or cooled slowly.

Advantages of Sealed Types

Sealed units have many advantages. They are not subject to variations due to changes in humidity. They have a high degree of stability. They can be made up and stored for periods of time with no worry of getting dirty. One disadvantage is that when crystals are sealed in a vacuum the absence of air around the crystal causes a slight change in frequency when the tube is evacuated. However, this change can be accurately allowed for when grinding crystals.

Some crystals are sealed in an atmosphere of dry air. Others, for high-power transmission, are sealed in neon or some other inert gas.

Temperature-Controlled Types

In temperature-controlled units, employed where the crystal frequency must be held constant over wide ambient temperature ranges, automatic temperature control is often provided in the holder. There is generally an integral heater winding, controlled by a thermostat, which maintains the crystal temperature within close limits.

Temperature-protected types are similar except for the fact that the arrangement used merely prevents the crystal temperature from falling below some fixed point, called the dew point. Usually this type of holder consists of a large temperature-controlled metal block, which encases the holder proper. Other temperature-controlled units are provided by placing any type holder in a box type oven. This arrangement provides very precise temperature regulation but is somewhat bulky.

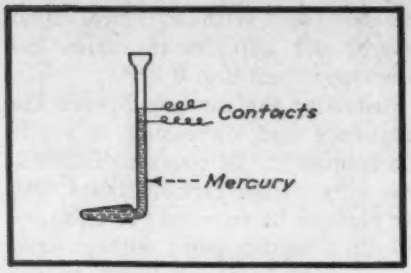


FIG. 11—Mercury thermostat

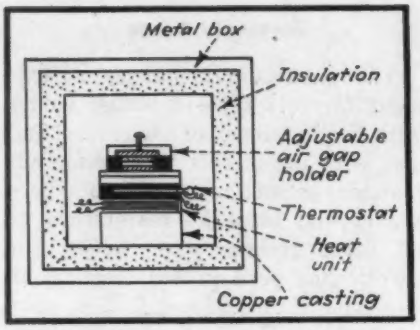


FIG. 12—Temperature-controlled unit

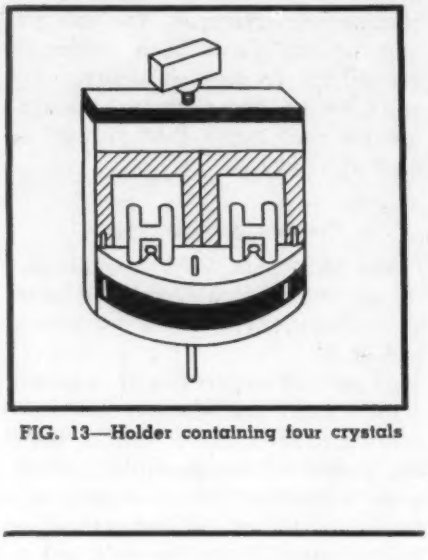


FIG. 13—Holder containing four crystals

It is obviously impossible to maintain a crystal at a temperature approximating room temperature without refrigeration. If a constant temperature is maintained solely by application of heat to the crystal, the fixed temperature is above room temperature, usually around 50 degrees C.

Viewed as a whole, the typical crystal oven comprises a heat-insulated chamber or box in which the crystal and its holder rest, an electric heating element for adding heat and a very sensitive thermostat for maintaing the temperature at a constant value. The oven or metal box is lined with a heat-insulating material. The thermostat is usually a very sensitive mercury-filled thermometer, into the stem of which has been fused two wire electrodes separated a short distance from each other as shown in Fig. 11.

By making the bulb of the thermometer large, so that it contains a relatively large amount of mercury, and by using a very small bore in the stem, a small change in temperature will cause a large change in the height of the mercury in the stem. When the thread of mercury makes contact with both of the electrodes in the stem a circuit is completed from one electrode to the other, which causes current to flow through a relay. This opens the circuit feeding the heating element and allows the oven to cool. The heating element is usually a resistor having a fairly large surface area, insuring uniform heating. See Fig. 12.

The heating and cooling period depends on the design of the oven. Generally, 30 seconds are required for the oven to heat and 1 minute to cool. The usual thermostat responds to changes of 0.1 deg. C. Typical ovens are held to 0.1 deg. C for X and Y cuts, and to 1 deg. C for BT and AT cuts.

Multiple Mounting Types

A recent trend in holders is the incorporation of more than one crystal in a holder. In some portable communication units one holder contains two crystals, one for transmitting and one for receiving. The shift from transmitter to receiver crystal is made by shorting out one of the oscillator circuits. This type holder facilitates construction of a compact electronic unit. As many as four crystals have been placed successfully in one holder. In these, the frequency desired is selected by means of a built-in, low-capacity switch. See Fig. 13.

Most companies are now doing considerable research on holders and several new types will probably "blossom out" after the war.

REFERENCES

(1) Elbl, L. A., Quartz Crystal Cuts, ELECTRONICS, p. 110, July 1943.
(2) Wein, S., Methods of Depositing Metal Films, ELECTRONICS, p. 102, Sept. 1943.

CHARACTERISTICS OF
Resonant Transmission Lines

Elementary characteristics of ideal or low-loss transmission lines are presented in convenient graphical form in this Reference Sheet. Voltage, current and resistance along resonant lines are portrayed, together with the equivalent resonant circuit at quarter-wave sections and the reactance for other lengths of open or shorted lines

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THE important part which transmission lines play in modern radio communication makes it useful to have available in compact graphical form for ready reference a graphical interpretation of the behavior of such lines. For simplicity of presentation, the curves and diagrams (next page) in this Reference Sheet have been plotted on the assumption that the lines are free from losses. The presence of a slight amount of attenuation will not appreciably affect the general shape of the curves, and hence the diagrams are useful for many practical applications as well as for the ideal loss free case. If the line has appreciable attenuation, however, the curves given here must be modified slightly to apply to actual conditions.

In drawing the curves, the line is assumed to be fed from a generator whose output impedance is equal to the characteristic impedance of the line. With this stipulation, the wave is absorbed and dissipated and is not reflected from the sending end. The curves are drawn for lines whose distant ends are open or shorted, corresponding to infinite and zero resistance termination at the far end.

All of the data for which the chart has been compiled, is available at a glance. For example, the length of line required to produce a high impedance, a low impedance, an inductive reactance, or a capacitive reactance are directly evident.

Reading from top to bottom, the chart shows the following data for transmission lines:

1. The reactance curves for lines of any length. While the curves shown apply for lines whose length is one wavelength or less, the curves are periodically repetitive, and hence may be extended to lines of any length. For lines longer than one wavelength, it is convenient to determine the line characteristics by subtracting an integral number of wavelengths from the line. The remaining length of line will then be less than one wave in length, and its characteristics may then be determined from the graphs.

2. The electrical equivalent reactance for lines of various lengths between exact multiples of a quarter wave line. When the reactance curve is positive, the electrical equivalent reactance is inductive, whereas it is capacitive for lines of such length that the reactance curve is negative. The ideal line, free from attenuation behaves either as a pure inductive reactance or as a pure capacitive reactance within any given quarter wave section. Actual lines, in which some attenuation is present, will also show a resistive component as well as the reactive component, but this is not indicated on the diagram.

3. The resonant circuit characteristics of the line at exactly each quarter wavelength. The ideal line behaves as a series resonant circuit and as a parallel resonant circuit alternately every quarter of a wave long. In the ideal case the line has zero resistance when the series resonant circuit is used to represent it, and has infinite impedance for those quarter wavelengths for which it behaves as a parallel resonant circuit. Actually, real physical lines have more than zero and less than infinite resistance at these points. The line is resonant at 90 deg. intervals for both open and shorted cases, and for quarter-wave intervals, the line behaves alternately as a series and as a parallel resonant circuit.

4. The resistance and the voltage and current distribution for open and shorted lines is given. For convenience the resistance curve is plotted along with the voltage and current distribution along the length.

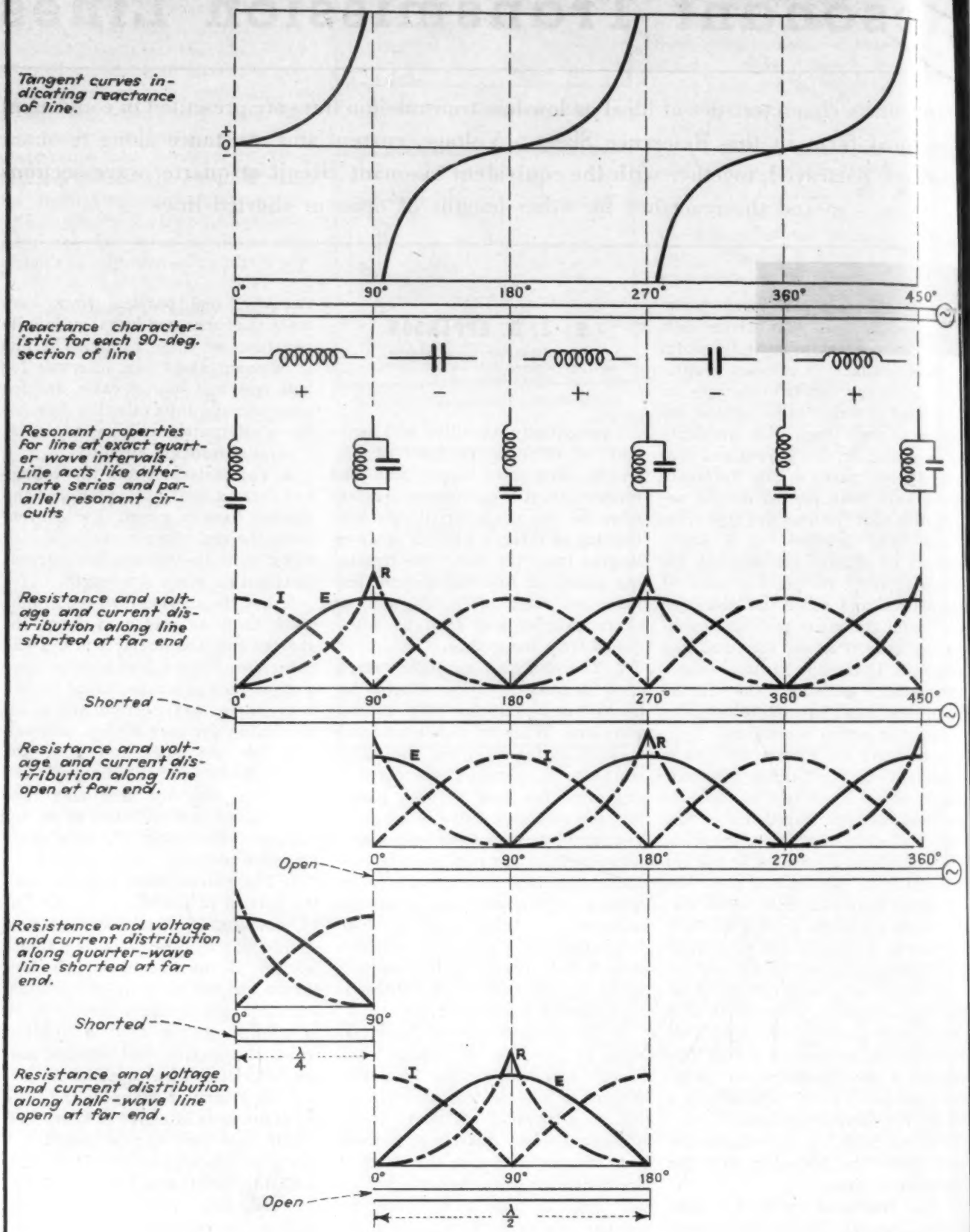
5. For the shorted line, the graphs show that, as measured from the shorted end, the line acts first as an inductance for the first quarter wave section, then as a capacitance for the next quarter wave section, and so on, alternately for each 90 deg. interval.

6. For the open end line, the graph shows that, as measured from the open end, the line acts first as a capacitance and then as an inductance, alternately, for each quarter-wave section.

7. The quarter wave diagram near the bottom of the chart is intended to show that a quarter wave section of line may be considered as a tuned circuit. If the line is slightly less than a quarter wave, it will present inductive reactance, whereas if it is slightly longer than a quarter wave, the section will assume the characteristics of a capacitance.

8. In a similar manner, the lowest diagram is intended to show that a half wave line may be considered as a tuned circuit element. If the line is slightly less than a half wave long, its reactance will be inductive, whereas the reactance will be capacitive if the line is slightly longer than a half wave.

RESONANT LINE CHARACTERISTICS



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New and amazing industrial processes and controls . . .

Yes, on every side the Horizons are becoming Broader as we enter the Age of Electronics.

Side by side with the achievements in the short- and ultra short-wave field has been the development of ALSIMAG Steatite bodies for high frequency insulators of extremely low dielectric loss together with high mechanical strength and rigidity—assuring constancy under any operating condition.

Today for our fighting forces . . . tomorrow for our customers, American Lava Corporation is pledged to these principles: Production to the highest known standards . . . Research to find a Better Way.

AMERICAN LAVA CORPORATION

CHATTANOOGA, TENNESSEE

ARMY E NAVY AWARDED JULY 27, 1942

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CHARACTERISTICS TAILORED TO YOUR REQUIREMENTS

Where stability is an important requirement, AlSiMag Steatite ceramics are unsurpassed for lending rigidity and permanence of alignment to electronic circuits.

TUBES AT WORK

Four-Microsecond Flash Unit 144
Electronic Control Developed for Helium-Shielded Arc Welding 146
Electronic Welding Fume Remover 148
Reclaiming Used Flashlight Batteries 148
Variable B Voltage Supply for Lab or Classroom 156
A Thermostatic Control System 166
Time Check for Studio Clocks 174
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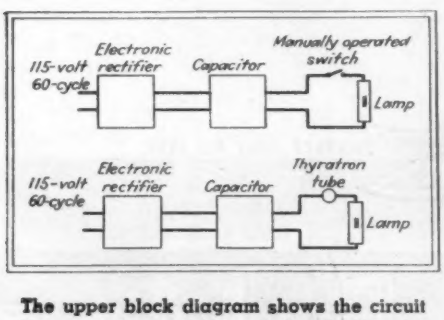
Classification Chart of RCA Cathode-ray Tubes 178

S. L. Bellinger and the high-speed portable flash unit. In his left hand he holds a phototube accessory for synchronizing the flash with the motion to be analyzed

Four-Microsecond Flash Unit

ANALYSIS OF HIGH-SPEED MOTION is now possible with a flash unit that has a speed of four millionths of a second. In this length of time an object traveling 2,000 feet per second moves but 0.096 inch and is practically "frozen" by a camera used in conjunction with the light.

The flash unit, developed by engineers in the laboratories of the General Electric Co., contains a 100-watt high-pressure mercury vapor lamp about the size of a cigarette. Flashing of the lamp is accomplished by charging a capacitor to a potential of 2,000 volts and then permitting it to discharge through the lamp. The rate of discharge is about 2,000 amperes, with a peak power of 4,000,000 watts, but due to the short duration of the flash the high current does not cause serious heating.



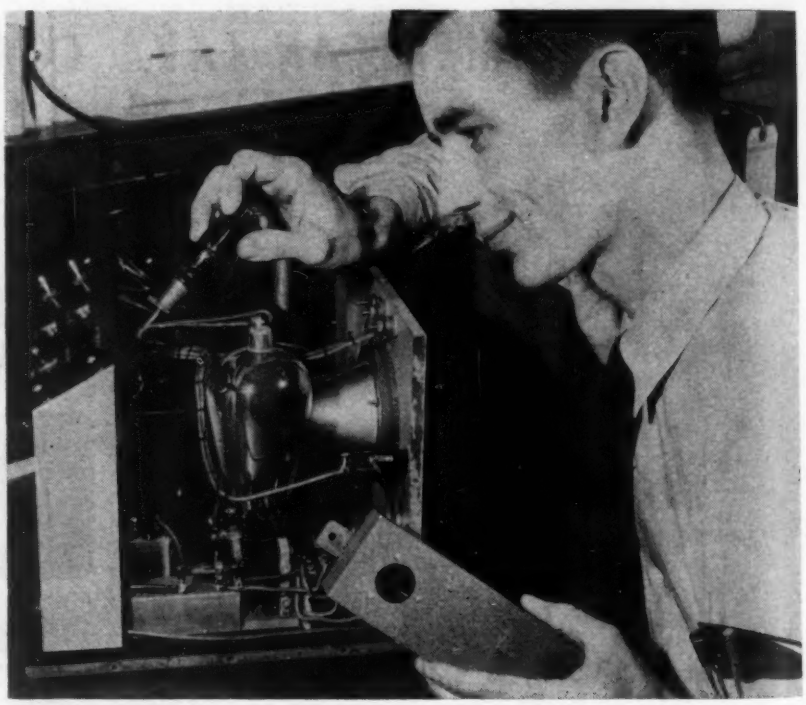
The upper block diagram shows the circuit for manual operation of the high-speed flash unit. The lower circuit includes a thyratron tube for automatic timing

Either of two methods shown in the block diagram may be used to flash the lamp. In one method a switch is placed in the discharge circuit and is operated manually to close the circuit between the capacitor and the lamp. The second method employs a thyratron tube as the switch to control the current through the lamp. With this method the flashing control over the 2,000-volt circuit is obtained by switching a 35-volt low-current circuit supplying the grid of the thyratron.

In order to actuate the thyratron and lamp at the proper moment, various synchronizing procedures may be used. These include making or breaking a light beam, tripping by the impact of sound or other compression waves, or making or breaking a simple electrical contact.

The amount of illumination obtained from the lamp at a distance of fifteen feet is photographically equivalent to over 1,000,000 foot-candles of light from tungsten lamps.

The life of the lamp is not definitely known, but one lamp was flashed at a rate of one flash every five seconds and was still in good operating condition after 330,000



Internal view of the flash unit for high-speed photography. The thyratron triggers 2,000 amperes at 2,000 volts from a capacitor through a mercury vapor lamp

Even the Big Inch Needs IRC RESISTORS

Vital arteries of supply in this mechanized war are America's pipelines. To maintain capacity flow, sludge and gummy deposits must be cleaned out at intervals. For this purpose a screw-type

ANOTHER IRC DEVELOPMENT

scraper propelled by the oil pressure is employed. When occasionally the scraper becomes stuck and plugs the line, the point of stoppage must be located to release the flowing oil.
But where—and how?

With the use of the Geiger-Mueller Counter, hours—and sometimes days—of search are saved. Modern scrapers contain radio-active metal which constantly emits an impulse message. When trouble occurs, these signals are picked up by the Counter, as the line is checked. At the point of greatest intensity the pipeline is tapped and the obstruction cleared away.

IRC engineering ingenuity plays an important part in the functioning of Geiger-Mueller Counters. Many specially designed IRC resistors and controls are employed in their carefully adjusted circuits.

If you have a design or engineering problem involving resistance units and you are seeking unbiased advice, why not come to Resistor headquarters at IRC? We make more types of resistors, in more sizes, for more applications than any other manufacturer in the world.

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TUBES AT WORK

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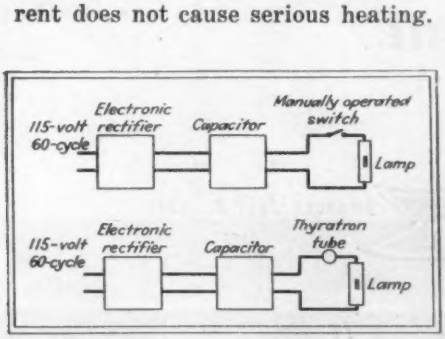

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ANOTHER IRC DEVELOPMENT

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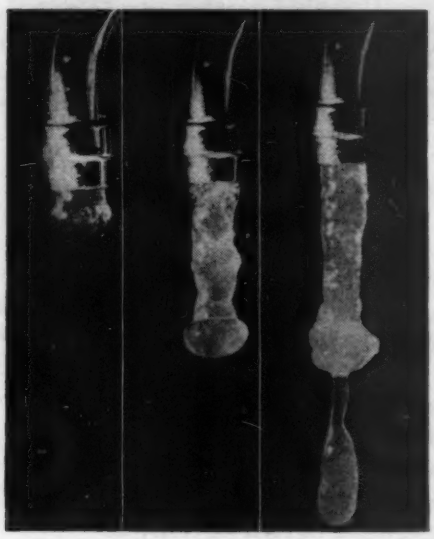
The mercury vapor lamp that burns but one second and has a light intensity equivalent to more than 1,000,000 foot-candles from tungsten lamps

flashes. The total additive time of this number of flashes approximates one second. Despite this brief period of life it is estimated by S. Lawrence Bellinger, who was active in development of the flash unit, that the lamp should last the average newspaper photographer several hundred years.



Three photographs of a faucet that has been suddenly opened. They were taken separately, at different intervals after opening the faucet. The picture at the right indicates that an air bubble was lodged inside the nozzle

Concerning the post-war possibilities of the unit, he further states, "Because of the pressure of war work, for which the unit was made, we have not been able to experiment fully with many fast moving objects. Rather, we have confined our efforts to using the device for studying high-speed machinery."

Electronic Control Developed for Helium-Shielded Arc Welding

THE DEVELOPMENT of both manual and automatic arc-welding equipment specifically designed for the welding of magnesium, magnesium alloys, aluminum and other high-strength light alloys under a protective shield of helium gas is announced by G-E. Availability of such equipment should make possible the greatly extended use in war production of the lighter metals whose welding demands precise control of concentrated heat and protection of the molten metal from the oxidizing effect of oxygen in the air.

The pioneering work was done years ago by H. M. Hobart and P. K. Devers, G-E engineers, who discovered that fusion welding of magnesium and aluminum could be done in atmospheres of helium and argon, using tungsten and carbon electrodes.

A unit that is completely automatic after preliminary adjustment is now in use in the G-E welding laboratory. It makes a smooth, clean weld under a shield of helium gas at rates up to 40 inches per minute on $\frac{1}{8}$-inch stock. This machine incorporates a new electronic motor control which enables the equipment to hold the proper arc-length even while the arc climbs and descends on curved surfaces.

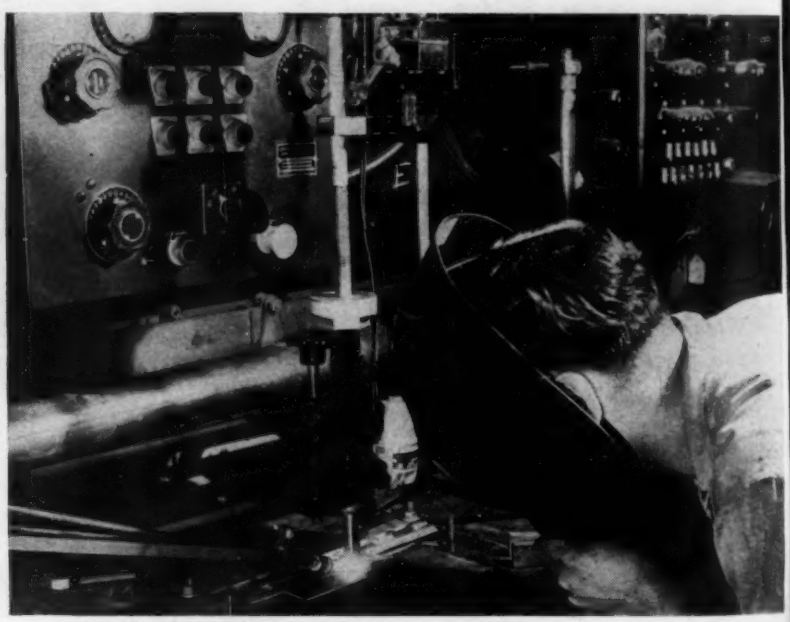
The filler metal is unreeled into work at the correct angle thro the small nozzle rod. The tungs electrode used to start and maint the arc extends through the ce of the rod that is perpendicular the work, and the helium gas is in around the electrode.

The rate at which filler metal fed can be adjusted to a constant u form feed into the arc, or a supp

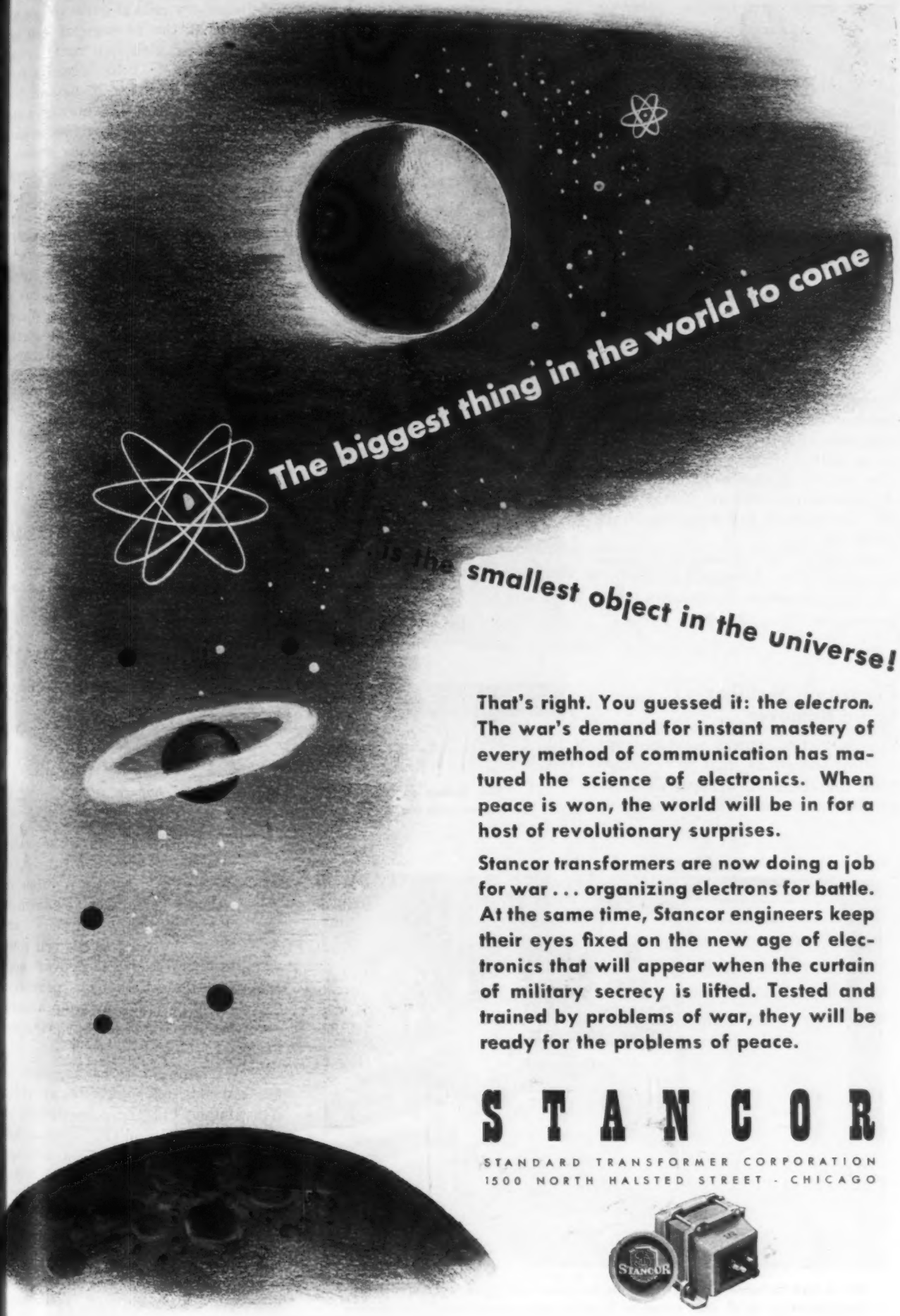
Close-up showing welding of magnesi plate. Extremely accurate control of rate of feeding the filler wire into the zone through the tube at the left results the uniform bead contour at the right

mentary control can be used to fe wire into the arc, withdraw it, a then feed it in again, all on a p determined cycle.

The heart of the manual heliu shielded arc-welding equipment is specially designed electrode hold which is arranged to hold either



Automatic helium-shielded arc-welding equipment in use. The electronic control panel at the upper right controls arc length, while the main control panel at upper left handles all the other welding operations. The slanting tube at lower left feeds the filler wire into the arc. The tungsten starting electrode and the helium gas nozzle are perpendicular to the work, which is clamped to a moving bed



That's right. You guessed it: the *electron.* The war's demand for instant mastery of every method of communication has matured the science of electronics. When peace is won, the world will be in for a host of revolutionary surprises.

Stancor transformers are now doing a job for war . . . organizing electrons for battle. At the same time, Stancor engineers keep their eyes fixed on the new age of electronics that will appear when the curtain of military secrecy is lifted. Tested and trained by problems of war, they will be ready for the problems of peace.

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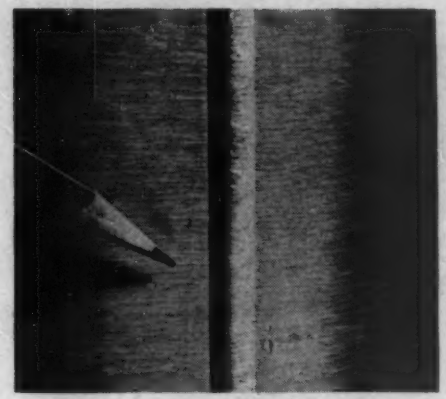


Example of butt joint made in ⅛-inch magnesium plate at rate of 24 inches per minute with G-E helium-shielded arc-welding equipment

tungsten or a carbon electrode, to conduct the welding current to the electrode and to surround the electrode with a stream of helium gas. The source of direct-current power for both manual and automatic welding is a standard G-E d-c arc-welding machine.

Supplies of helium have been made available by the Bureau of Mines for welding, especially for use in war production.

Electronic Welding Fume Remover

THE OBNOXIOUS FUMES produced by welding operations may be removed from the scene of welding activity by electronic means. The fumes are drawn through flexible metal hoses to a portable Westinghouse Precipitron electrostatic air cleaning unit, where 90 percent of the fumes and air-borne particles are removed before the air is returned to the room.

Reclaiming Used Flashlight Batteries

By MAURICE E. KENNEDY

Communications Engineer
Los Angeles County Flood Control District
Glendale, California

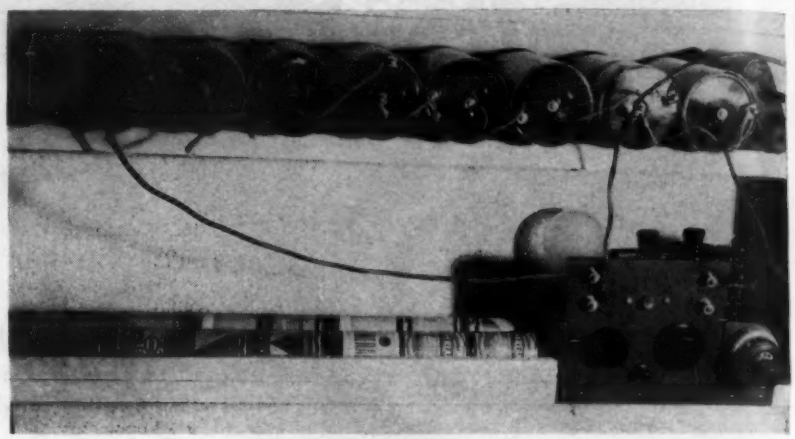
IN THE INTEREST of material conservation, the extension of the useful life of flashlight cells and other forms of dry batteries has considerable merit.

The process of depolarizing and reclaiming dry cells is quite simple and consists of the passage of 150 milliamperes of direct current through a number of the cells in series for a period of four hours or longer.

The charging device may be a simple half-wave rectifier with a suitable voltage control rheostat as shown in Fig. 1, or it may be a more elaborate full-wave rectifier with automatic voltage regulation.

Maintenance of the 150-ma charging current through a given number of cells is the determining factor in designing the rectifier. In large industrial plants, where the turn-over of flashlight cells by night guards and others is fairly great, it may be more economical to build a charger capable of charging a large number of cells at a time.

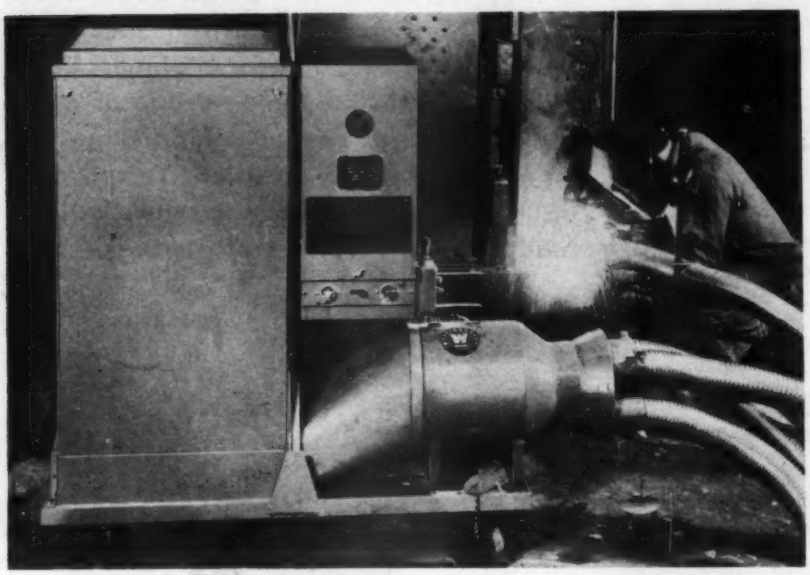
Battery racks should be built to accommodate the desired number of cells in series somewhat as shown in the photo. Spring contacts are provided at the ends of the cell rows to maintain pressure to provide contact between cells. Some provision should also be made to jump around cell rows when smaller batteries are in need of charging.



The power supply is mounted on one of the battery racks, where cells are held in contact by springs at the end of each row

A d-c milliammeter capable of reading 150 ma should be provided if available, but the substitution of a flashlight bulb of the 300-ma, 3.8-volt size will give a good average check. By using an external meter to set the original values, it is soon possible for the person operating the device to become accustomed to the correct brilliance of the lamp.

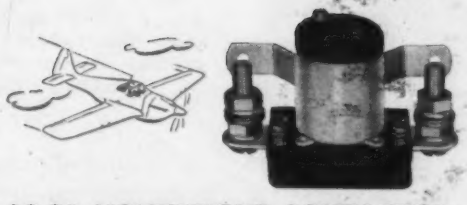
Care should be taken in selecting the cells to be reclaimed, as leaking



Fumes and air-borne particles may be removed from three welding positions simultaneously with this portable Westinghouse electrostatic air cleaner

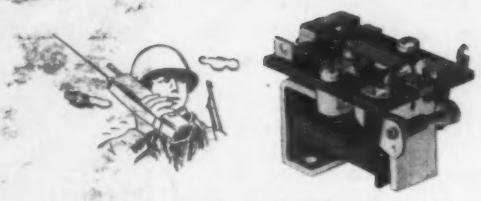
Relays by GUARDIAN

FOR EVERY CONTROL NEED



SC-25 LIGHTWEIGHT CONTACTOR

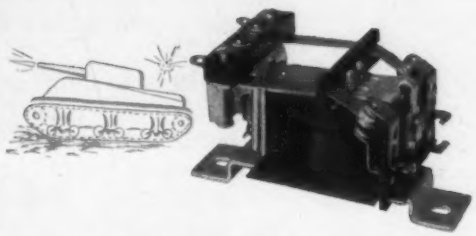
A lighter, more efficient contactor for AAF type B-4 continuous duty applications. Double wound coil draws 2 amperes closing contacts firmly. Then an auxiliary switch cuts in a higher resistance reducing current to .18 amperes. Advantages are lighter weight, firm closing of contacts, smaller current drain. Weight: 21 oz. Write for bulletin SC-25.



SERIES 195 MIDGET RELAY

One of the smallest of all relays. Built for aircraft and radio applications where space and weight are at a premium. Contact rating: 2 amps. at 24 volts D.C. Switch capacity up to double pole, double throw.

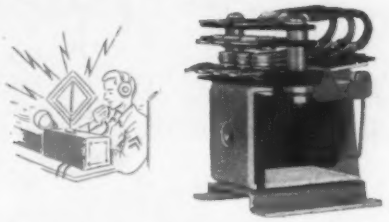
Contacts withstand vibration test in excess of 10 G's. Coil resistances up to 2,000 ohms. Weight: .85 oz.



SERIES 165 VIBRATION RESISTANT

Counterbalanced armature and sturdy construction throughout give this relay an unusual resistance to vibration. Silver contacts are rated at 12½ amperes in combinations up to double pole, double throw.

Rating for aircraft is 8 amperes at 24 volts D.C. Available with ceramic insulation for HF and UHF applications.



SERIES 345 RADIO RELAY

A general purpose radio relay designed for aircraft use. Contact combinations up to three pole, double throw. Coil resistances range from .01 ohm to 15,000 ohms. Standard voltage: 16-32 volts D.C. Available with delayed release or delayed attract. Weight: 6½ oz. Also built for A. C. operation (Series 340).

GUARDIAN ELECTRIC

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A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

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INTEGRITY of DESIGN
. . . a plus feature of all
Jackson Instruments

No matter what your requirements for measurement of voltages, currents, and other values, the JACKSON Model 642 Multimeter will serve you well. This highly sensitive DC voltmeter has ranges up to 5,000 volts . . . also complete AC voltage ranges; also provision for ohm measurements up to 30 megohms. Other ranges are DC milliamperes, DC microamperes, DC amperes and decibels.

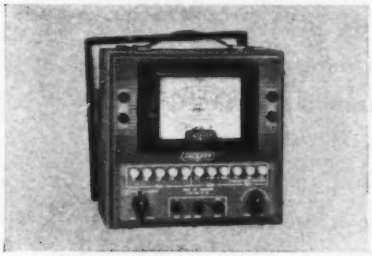
In daily use, in Industrial and Development Laboratories—as well as in the Armed Services the world over — the INTEGRITY of DESIGN, and basic high quality of this Instrument, has been thoroughly proved.

Another triumph of JACKSON engineering and INTEGRITY of DESIGN (also shown below) is the Audio Frequency Oscillator Model 652. This Instrument operates on the resistance-capacity tuned principle . . . has splendid stability . . . continuous frequency range from 20 to 20,000 cycles with excellent wave form. Model 652 is simple in operation, gives positive, trouble-free results; and is fulfilling a critical, full-time war job.

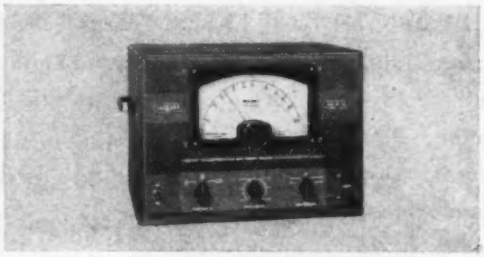
Production of JACKSON Instruments has been vastly increased to meet urgent military needs. All JACKSON equipment continues available, subject to W.P.B. regulations. Write for catalog—and for an explanation of the full meaning of *INTEGRITY* of *DESIGN*.

★ ★ ★

All Jackson employees—a full 100%—are buying War Bonds on a payroll deduction plan. Let's ALL go all-out for Victory.



Model 642 Multimeter



Model 652 Audio Oscillator

JACKSON

Fine Electrical Testing Instruments

JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO

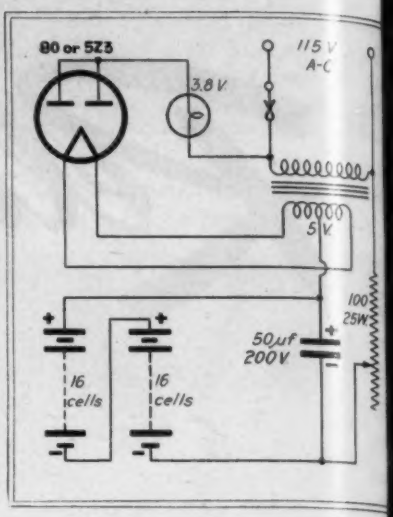


Fig. 1—Circuit used for reclaiming dry cells. The rheostat is used to adjust the charging current to 150 ma when fewer cells are being charged

cell cases will damage the flashlight when returned to service. It is generally good practice to discard any cells with suspicious looking bulges or leaks in the zinc cases.

The rejuvenation period will vary with the individual cell and is no doubt due to the internal moisture condition of the cell, the cell formula used in its manufacture, the age of the cell, the type of service in which it was expended during its first or normal life cycle, and other factors. Most cells will return to above normal voltage within four to eight hours.

A voltage-stabilizing period of about six hours should be observed following the charging period as a final check on the cell before returning it to service. This shelf period will also permit the cell to return to normal voltage and prevent the burning out of flashlight bulbs often experienced with freshly charged batteries.

Numerous life tests have been made on new and reclaimed flashlight cells of different makes. Typical curves of five life cycles are shown in Fig. 2. These tests were made with three cells connected in series in order to arrive at an average condition for the given type of cell. Placing a 250-ma load on the cells for a 30-minute period, then removing the load for a 15-minute rest period was considered to be a fair approach to actual operating conditions.

Judging from numerous tests with cells of all makes, it has been found

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—We call it the [redacted] room at the plant because that's where we make those very special [redacted] microphones. But this we can say. New techniques in microphone manufacture involve such extreme care that workers operate in dustproof glass enclosed areas which are air conditioned and humidity controlled. Precision made—they are designed to stand up and perform under extremely difficult combat conditions.

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SHURE MICROPHONES

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Designers and Manufacturers of Microphones and Acoustic Devices

look ahead

and look to Sperti

EVEN with the rapid advancement of science, spurred by war demands, we have seen only a glimpse of what lies beyond the uncharted horizons.

The contributions which Sperti has made in the field of electronics, irradiation and fluorescent lighting (as well as biodynes with all they imply in the field of medicine) are but a promise of significant *new* developments to come.

For beyond Sperti are laboratories devoted to pure research . . . staffed by scientists whose sole purpose is to unselfishly roll back the horizons of human knowledge for the betterment of mankind.

Sperti, Inc. exists to make their mature discoveries available in applicable form.

Even now, though Sperti is almost wholly engaged in war work, there may be a discovery which has a place in your postwar product planning.

It will pay you to keep Sperti in mind—as you turn *your* mind toward tomorrow.

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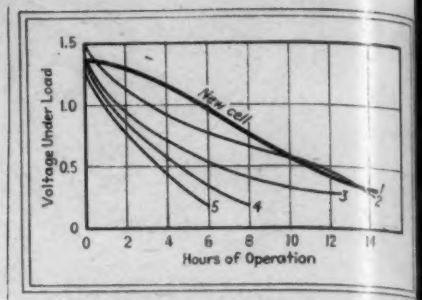

Fig. 2—Life cycle of a flashlight cell with a load of 250 ma when new (curve 1) and after repeated recharging (curves 2, 3, 4 and 5). The load was applied for 30-minute periods and removed for 15-minute periods to simulate operating conditions

possible to repeat the rejuvenation process and corresponding life cycle of the better grades of dry cells about four times. A few cells have been depolarized and reused over thirty times in actual practice. The normal discharge conditions of these were not as severe as the test loads, and the exceptional cells were individuals and not groups of three. Best results were also noted from fresh new cells, expended over periods of about two weeks, reclaimed before they were entirely dead, and reused under similar conditions. Cells that are permitted to stand in a totally discharged condition for long periods can seldom be reclaimed.

It is desirable to keep small numbers of dry cells in rotation through the discharge and recharge cycles in preference to charging large numbers of cells to be expended in shelf life before returning to service.

Other types of dry cells, such as the familiar No. 6, the numerous types of hearing-aid batteries, radio batteries, and others have been reclaimed with somewhat less success. The larger cells take a fairly long charging period but seem to respond in a satisfactory manner if they are not too old. Again it would appear that only the cells with sufficient internal moisture in the electrolyte can be reclaimed.

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Variable B Voltage Supply for Lab or Classroom

By A. H. BROLLY, *Senior Instructor*
and
J. L. LAHEY, *Lab. Instructor*

U. S. Naval Training School (Radio Material), Chicago, Ill.

A SOURCE OF VARIABLE B voltage is often required in laboratories, service shops, and classrooms. An important application is found in many of the wartime radio courses where experiments dealing with vacuum tube characteristics are performed by large groups of students.

Variable B voltages can, of course, be provided by means of variable transformers or resistance dividers but cost, present availability and other disadvantages leave room for another approach to the problem.

The device to be described in this article can be put together from simple, inexpensive parts which are obtainable at present. It can be added to any small power supply having a couple of spare filament windings and its performance is ideal for the applications suggested above.

Briefly, the principle involved is to employ a tube having low plate resistance as a variable resistor, its value being varied by means of the grid bias to effect the desired control. In the diagram, Fig. 1, a 6A5G is used as the resistance which is varied from an equivalent value of 900 ohms to practically infinity by a change of bias from zero to −100 volts. The 2A3, 6A3 or 6B4G could be used in lieu of the 6A5G if desired.

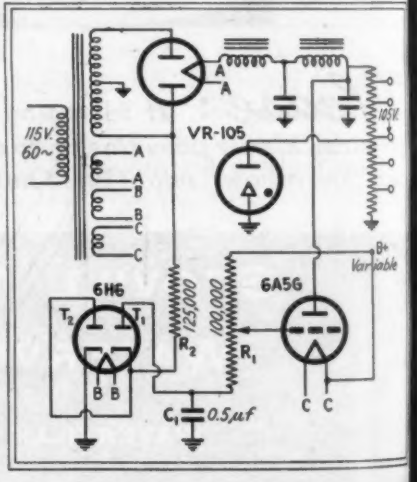

Fig. 1—Circuit of variable-voltage power supply that employs a vacuum tube as the output voltage control

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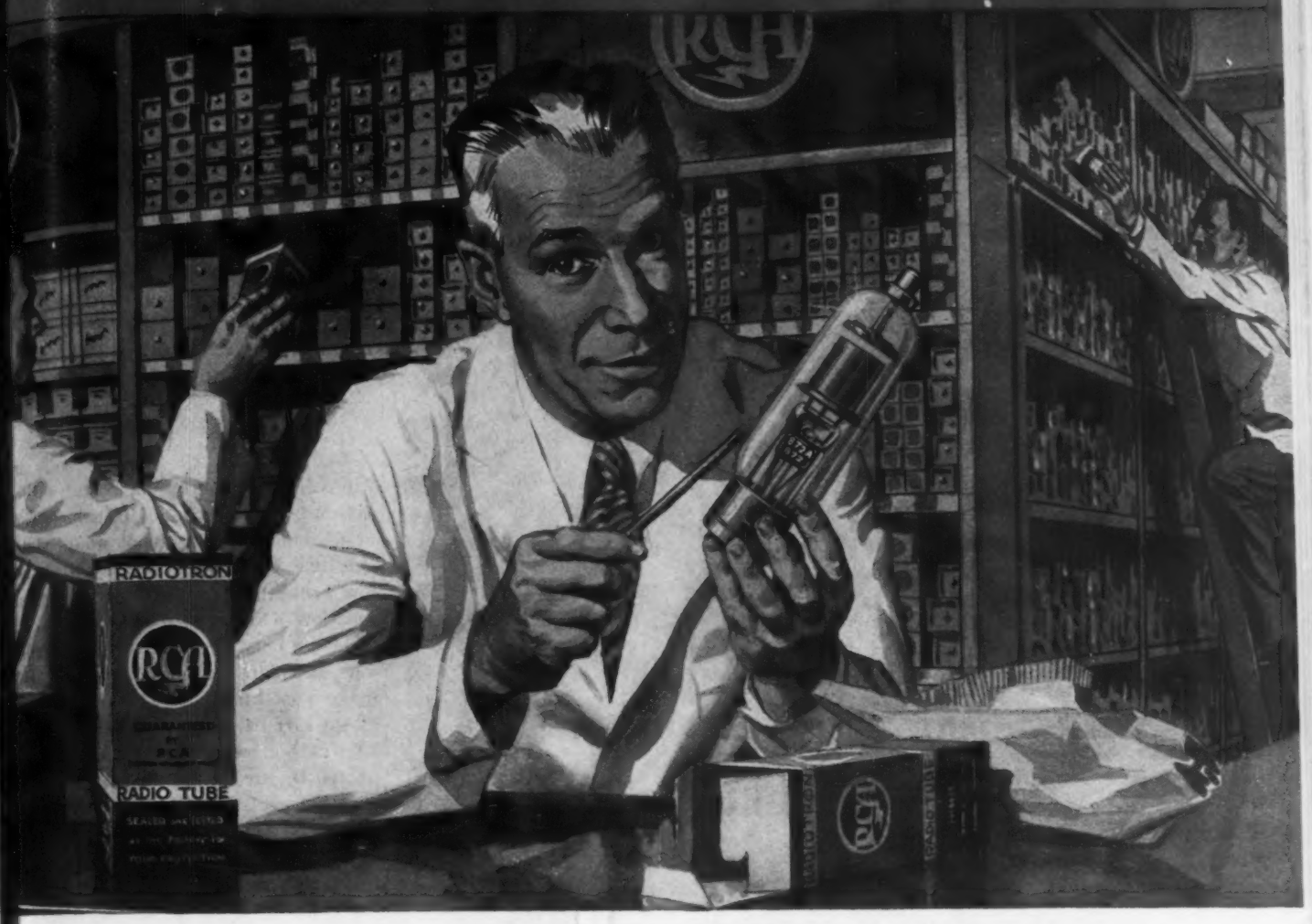

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The cathode of the tube in this position is above ground by the amount of the output voltage, hence a separate heater winding is required which can be allowed to assume this potential. One tube of the type suggested is good for an output of 60 to 70 ma. Two or more tubes may be connected in parallel to handle more current. When tubes are paralleled, suppressor resistors must be placed in series with their grid leads to prevent parasitic oscillations. Anywhere from 50 to 500 ohms is satisfactory, but the resistors should be connected directly to the socket pins as close as practicable.

Bias Supply for Control Tube

The bias for the control tube or tubes is provided by separate rectification with a type 6H6 tube. The 6H6 is particularly well adapted to this use because of availability and low cost and because it is designed to allow a difference of potential of 330 volts between heater and cathode. The separate cathodes of the 6H6 make possible an important feature of the circuit, as will be shown later. The cathode of diode T_1, being connected to one end of the main transformer, rectifies the peak negative swings. This rectified current charges capacitor C_1, and, passing through potentiometer R_1, provides the required bias. R_1 and C_1 act as a filter to smooth out the bias voltage. Ripple in this bias affects the plate current of the control tube and in-

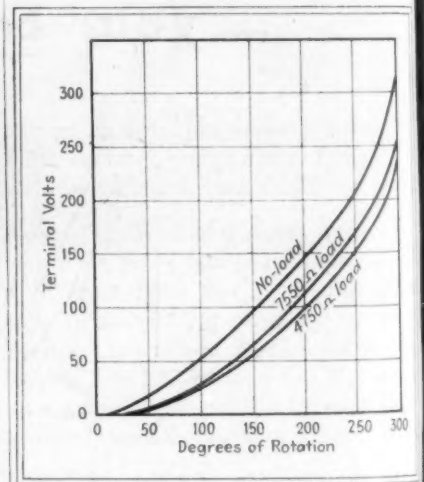

Fig. 2—Voltage changes produced at varying degrees of rotation of control potentiometer. The two lower curves show typical load conditions, and the third shows readings obtained on a 1000 ohm-per-volt meter with no other load

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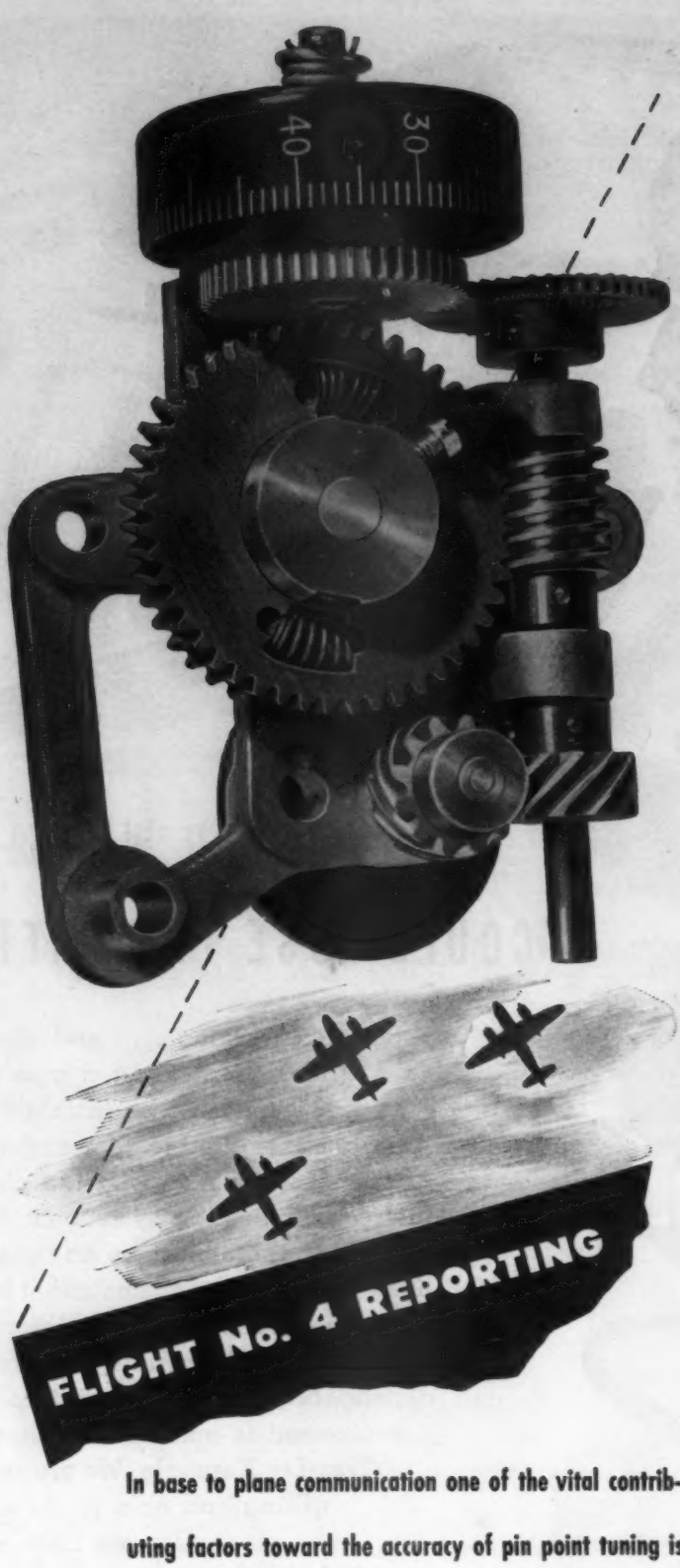
troduces ripple in the output voltage.

The values of R_1 and C_1 given in Fig. 1 were found to introduce a 60-cycle ripple of 5 volts rms. At very light loads this ripple persists down to low d-c terminal voltages where it is appreciable. However, this is not objectionable for tube characteristic measurements and such applications and at even moderate loads it is negligible throughout the range. If less ripple is required, a larger value of C_1 may be used or the control tube can be placed between sections of the main filter. The peak voltage on the capacitor for the circuit shown in Fig. 1 is only 109 volts, so a small capacitor can be used. It may have a tendency to reverse polarity by a few volts under some circumstances so it is advisable to use a paper rather than an electrolytic capacitor.

Effect of Potentiometer Taper

For potentiometer R_1, 1000 ohms is a good value as it gives a value of series resistance in the grid circuit of the control tube which is within the manufacturers' rating. It also permits filtering with economical values for C_1. A linear taper is satisfactory. If any other taper is chosen care should be taken to connect the potentiometer in such a way as to compensate for the typical curvature in the control characteristics illustrated in Fig. 2, otherwise it will exaggerate this slight disadvantage. Some nominally linear potentiometers have considerable taper effect at both ends of the scale. These are particularly unsatisfactory for this application. The dissipation in this potentiometer will not exceed one watt if other quantities are approximately as shown in Fig. 1, hence an ordinary receiver-type volume control potentiometer can be used.

The 125,000-ohm fixed resistor R_2 connecting the bias tube with the transformer serves to drop the high voltage to a value suitable for bias. In ordinary supplies delivering around 250 volts, this resistor should have a rating of 2 to 3 watts. The advantage of placing this voltage-dropping resistor on the a-c side of the rectifier rather than the d-c side will be apparent when the function of diode T_2 is considered. With its inverted connection T_2 passes current when T_1 is inactive, thus pro-



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ducing a voltage drop in R_3 on bot halves of the cycle. This accomplishe two purposes. First, it keeps th peak inverse voltage within the rate limit of the tube and second, it keep the cathode-to-ground potential fro rising above the rated cathode-t heater voltage. This makes it po sible to operate the 6H6 heater o a supply that is used for other tube where grounding the heaters is r quired. Operation of the 6H6 heate from the same supply as the contr tube is not advisable.

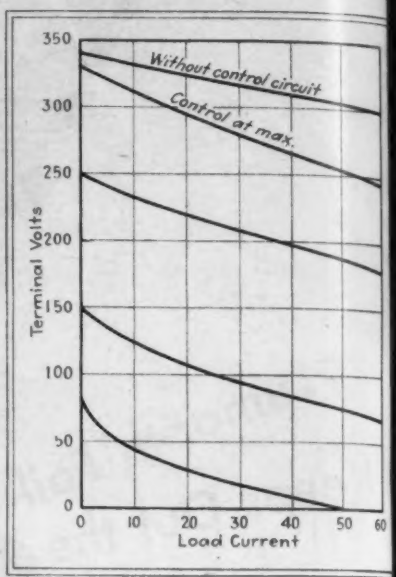

Fig. 3—Regulation curves obtained wit voltage control at various settings. Th top curve is for the power pack alone without the control circuit

The currents rectified by the 6H are greatest when there is no loa on the power supply and when th control is set for maximum outpu voltage. Under these conditions th direct current in each section of th 6H6 is 3 ma, which is well belo the rating for the tube. The pea cathode-to-ground voltage and th peak inverse voltage on section T are only about 120 volts, which i well below ratings, assuring reliabl operation.

Balancing Reverse Current Flow

The current through potentiome ter R_1 must return either through th control tube or the load. This cur rent is in the reverse direction t the principal load current and tend to develop a small reverse voltag across the load when the control i turned down. This is remedied b finding a balance between R_1 and R

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Fig. 4—Complete power supply with va uum tube voltage control

such that the control tube is nev completely cut off. It will then pa enough current to just offset the bi current and bring the terminal vol age down to zero at the extreme se ting of the control potentiometer.

Fig. 2 shows the control characte istics with three typical loads. The are not linear but their slope is suf cient near both ends so that th control is reasonably effective at th extremes. This is convenient fo work where it is desired to mak fine adjustments of voltage throug out the range. Since the device essentially a series resistance devic it might be expected that its regul tion would be very bad but this not the case, as may be seen fro the regulation curves in Fig. 3. Sinc a supply of this kind will probabl not be used for intermittent loa the regulation is quite satisfactor

Where a supply with this type control is used for vacuum tu characteristic tests, it is convenie to provide a constant screen suppl This can be done by adding a volta regulator tube (VR105 or VR150 connecting it with a suitable seri resistor to a point ahead of the co trol tube. A separate output termin must then be provided for connec ing the screen circuit across the V tube.

A considerable number of the supplies have been built for use the laboratory of the Naval Trai ing School (Radio Materiel), Ch cago, Illinois, where they have be in use for many months and hav proved very useful and satisfactor

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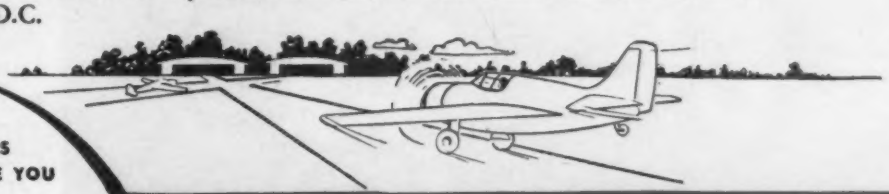

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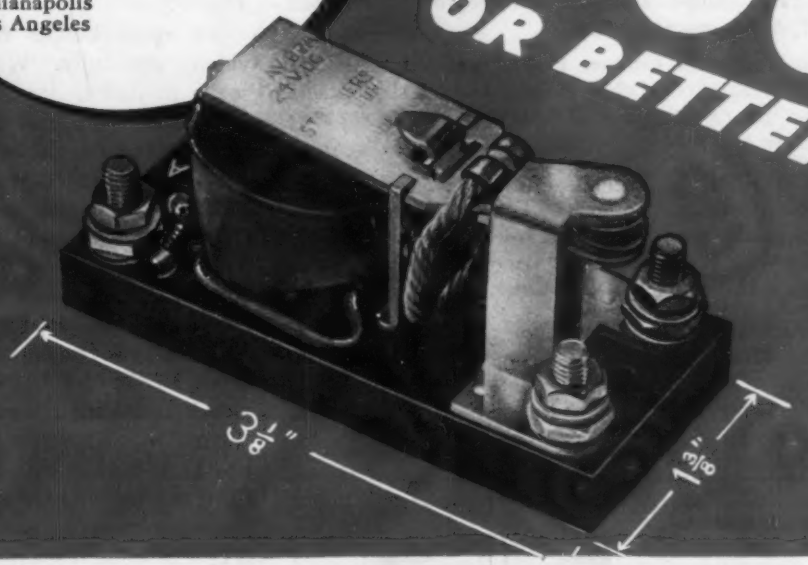

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WILCO

A Thermostatic Control System

By JACK G. ROOF

Oregon State College, Corvallis, Oregon

IN AN EARLIER NUMBER of th journal a phototube temperatu regulator is described by Weinland In this controller the emf of thermocouple is balanced out by th voltage drop along a slide-wire po tentiometer attached across a ba tery. Any change in emf of th thermocouple, due to deviations furnace temperature from that d sired, results in a movement of a ga vanometer mirror which reflects beam of light onto one of two photo tubes. An electrical circuit th either turns the heater off or o depending on which of the two photo tubes was activated. With Wein land's regulator, "overshooting" phototube does not cause a loss control; thus no mechanical stops ar necessary on the galvanometer.

A regulator that operates on th principles mentioned above was de vised independently by the autho and was used for a time in therm stating a molten lead bath at 40 deg. C. However, the thermocouple potentiometer control for the ga vanometer was soon replaced by resistance thermometer-Wheatston bridge system, which offers certai improvement in sensitivity and sta bility. The circuit used is shown i Fig. 1.

To start heater H, relay S_1 i closed manually. When closed, S_1 locks in due to its sending curren through its own coil. As the tempera ture rises and resistance the mometer R_1 increases in resistance the bridge approaches balance. Th galvanometer swings the light bea in a clockwise direction. While pho totube VT_1 is activated, relay S_1 closes, which act would normall close S_3. As the light beam swing from VT_1 onto VT_2, relay S_2 is acti vated, breaking the circuit throug the coil of S_3; when S_3 is open, th heater is turned off. The heat is o until the light beam returns to VT_1 Coasting past a phototube or th presence of vibrations, causing mul tiple impulses to be sent to the photo tubes, does not result in loss o control.

The circuit indicated by amplifier A_1 and A_2 is described by RCA[3] and shown in Fig. 2. The resistances R_6

SEPARATE LEADS AND WIDER PIN SPACING

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Here are two RCA Cathode-Ray tubes that will fill many war applications. Both have electrostatic-deflection with a separate lead for each deflection plate and for the cathode; thus balanced deflection can be obtained. New base designs, too, with wide spacing between high- and low-voltage leads. Both are on the Army-Navy Preferred list.

RCA-2AP1: A 2-inch high-vacuum tube, similar to the RCA-902, but with separate leads to all electrodes, and higher anode voltage rating. Magnal 11-pin base.

RCA-3BP1: A 3-inch high-vacuum tube. Electrostatic focusing and deflection. Green fluorescence. Medium persistence. Neck diameter, 2 inches. Overall length, 10 inches. Diheptal base.

For other important uses here are three outstanding RCA Cathode-ray tubes

RCA-3EP1/1806P1: Similar to RCA-3BP1, except: a) Neck diameter is 1⅝ inches; b) Magnal base; c) Cathode connected to heater inside of the tube.

RCA-5CP4: A 5-inch, high-vacuum tube with extra high voltage electrode, (anode No. 3). Electrostatic deflection and focusing. Separate leads to *all* electrodes. White fluorescence. Medium persistence. Neck diameter, 2 inches. Overall length 17 inches. Diheptal base. Anode No. 3 brought out to snap terminal on bulb.

RCA-7CP1/1811P1: A short, 7-inch, high-vacuum tube. Magnetic deflection. Electrostatic focusing. Green fluorescence. Medium persistence. Neck diameter, 1⅝ inches. Overall length, about 13½ inches. Octal base. Separate leads for all electrodes. Anode No. 2 brought out to snap terminal on bulb.

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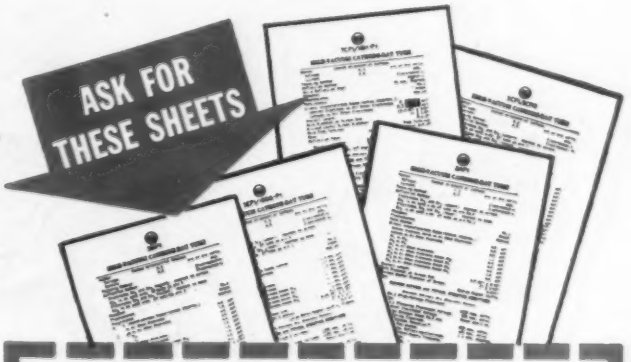

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Radio Corporation of America
509 South 5th St., Harrison, N. J.

Please send me the data sheets on the following tubes:

☐ 2AP1 ☐ 3BP1 ☐ 3EP1
☐ 5CP4 ☐ 7CP1

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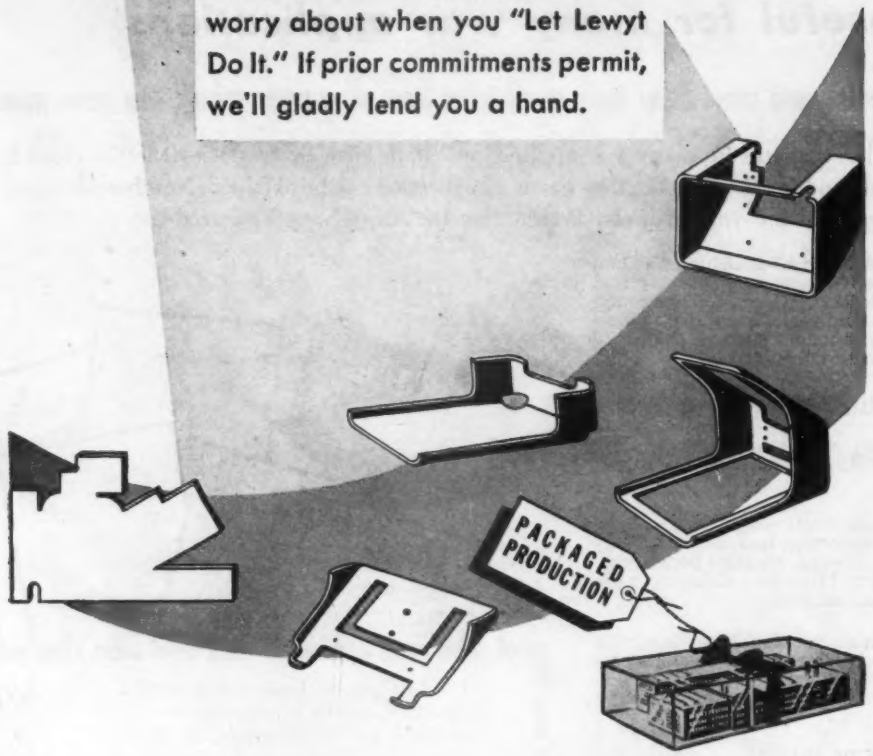

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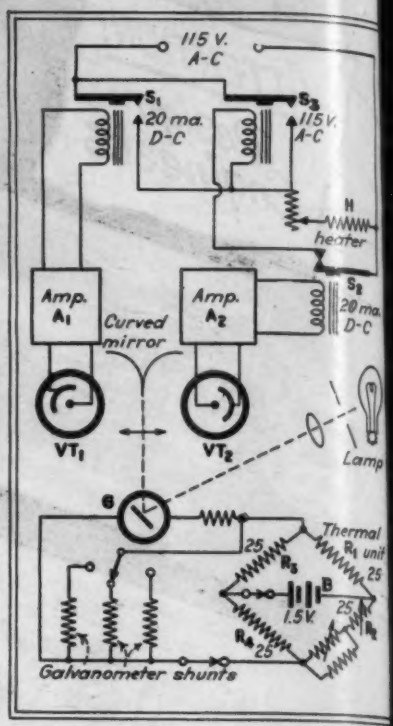

Fig. 1—Complete circuit of thermostatic control. Light from the lamp is reflected to one of two phototubes by a mirror galvanometer that responds to unbalance in the bridge circuit

R_3 and R_4 should be of a material of low temperature coefficient to avoid the necessity of thermostating them at room temperature; nichrome was considered to be satisfactory.

In Weinland's circuit a change in the voltage of the battery opposing the thermocouple would result in a change in the temperature at which the regulator was working. In a Wheatstone bridge a decrease in battery voltage would result in decreased sensitivity of the apparatus but the controlled temperature would not be affected. This is a rather important item in using a regulator over a long period of time.

The sensitivity of the Wheatstone bridge system described is greater than that of a thermocouple. For an iron-constantan couple the increment of voltage is only about 55 microvolts per degree at 400 deg. C when no load is drawn. To calculate the sensitivity obtainable with a bridge, consider the temperature coefficient of nickel wire. The resistance r_t of a wire at temperature $t°$ C is often expressed as an empirical function of t and r_o, the resistance at 0° C

$$r_t = r_o(1 + \alpha t + \beta t^2)$$

Differentiation and elimination of r_o gives

$$\frac{dr_t}{dt} = r_t \frac{\alpha + 2\beta t}{1 + \alpha t + \beta t^2}$$

THE "Wondergift" PALM

Only the gods can read the entire electronic palm, but electronic engineers are learning fast. On their boards already are "wondergifts" to man that almost stagger the imagination.

Each new electronic advance calls for a special motor or generator—often a super-special one. That, implies a motor builder in position to work out the exacting power problems involved. That, means Leland.

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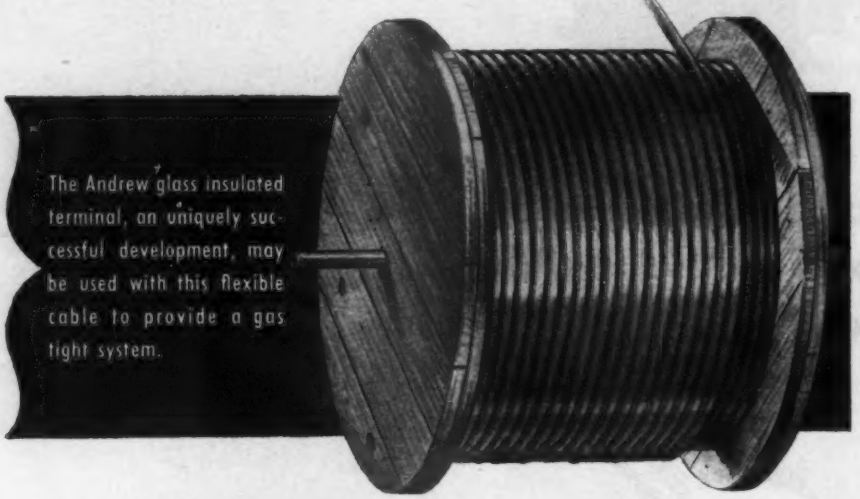

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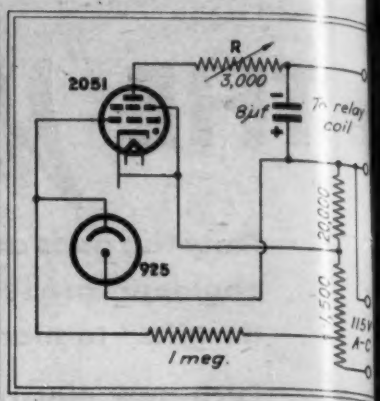

Fig. 2—Circuit of amplifier used at A_1 a A_2 of Fig. 1. Resistor R limits plate curr to less than 25 ma. and its value depe on the impedance of the relay

For nickel these coefficients α a β are given [3] as 5.44×10^{-3} and 6.0×10 respectively. Thus a nickel wire h ing a resistance of 25 ohms at deg. C would, at that temperatu have a coefficient of approximat 0.062 ohm per degree.

That such change in resistance usable with an insensitive galvano eter may be shown from the equ tion of a bridge out of balance [4]. we let R be the resistance of each three equal arms and $R+\Delta$ be that the fourth, and let V be the e across the bridge, then by appli tions of Ohm's and Kirchhoff's la one can show that the current pas ing through a galvanometer of r sistance R_g will be

$$i_g = \frac{V\Delta}{4R^2 + 4RR_g + 3R\Delta + 2R_g\Delta}$$

or for values of Δ that are small co pared to R and R_g

$$i_g \backsimeq \frac{V\Delta}{4R(R + R_g)}$$

If the sensitivity of the galvano eter is given in terms of volta

$$E_g \backsimeq \frac{R_g V\Delta}{4R(R + R_g)}$$

With applied emf of 1.5 volt Wheatstone resistance of 25 ohm and a temperature change of o degree at 400 deg. C, a galvanomet with coil resistance of 100 ohm would have a current flow of abo 8 microamperes or a voltage dr of about 800 microvolts (compare to 55 microvolts for an iron-consta tan couple). Galvanometers in th $25 price range (e. g., the Leeds an Northrup type P) have sensitivitie of the order of 0.001 to 0.01 micr amperes or about 1.5 microvolts p millimeter at one meter. One degr temperature change would give de flections of the order of 500 to 10

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mm. If this were the limiting fac temperature regulation of the or of ±0.01 deg. would be poss ble w such galvanometers by using pho tubes only 0.5 meter from the g vanometer mirror. The sensitiv of the system may be doubled having two opposite arms of t bridge serve as resistance th mometers in the bath (i. e., R_t well as R_1).

If a more sensitive galvanome is used, or even to protect a l sensitive one while approaching t desired temperature, one should u shunts across the galvanometer. T multiple-contact switch should be the shorting rather than the n shorting type; thus one will ne throw the full emf of unbala across the galvanometer wh switching from one shunt to anoth

There is an upper limit to t temperature at which a resista thermometer may be used beca of its oxidation or changes in insu tion. Nickel permits higher tempe tures than does iron, while platinu withstands still higher temperatu but at the expense of decidedly lo temperature coefficients. The sen tivity of response is greater at lo temperatures. Nickel wires havi resistance of 25 ohms at the specif temperatures would have the follo ing coefficients at those tempe tures: 200 deg. C—0.084 ohm p degree; 400 deg.—0.062; 600 deg 0.049.

In the author's use of this co troller full benefit of the possibiliti was never derived due to the hi thermal lag of the air space betwe the alundum-covered heating co and the iron vessel holding t molten lead. The lag was so lar that a low-resistance shunt was ne essary across the galvanometer prevent overly large swings of th instrument. The extreme variatio in temperature as measured on a iron-constantan thermocouple wi a potentiometer were less th ±0.25 deg. as read at one-minute i tervals over periods of one hour.

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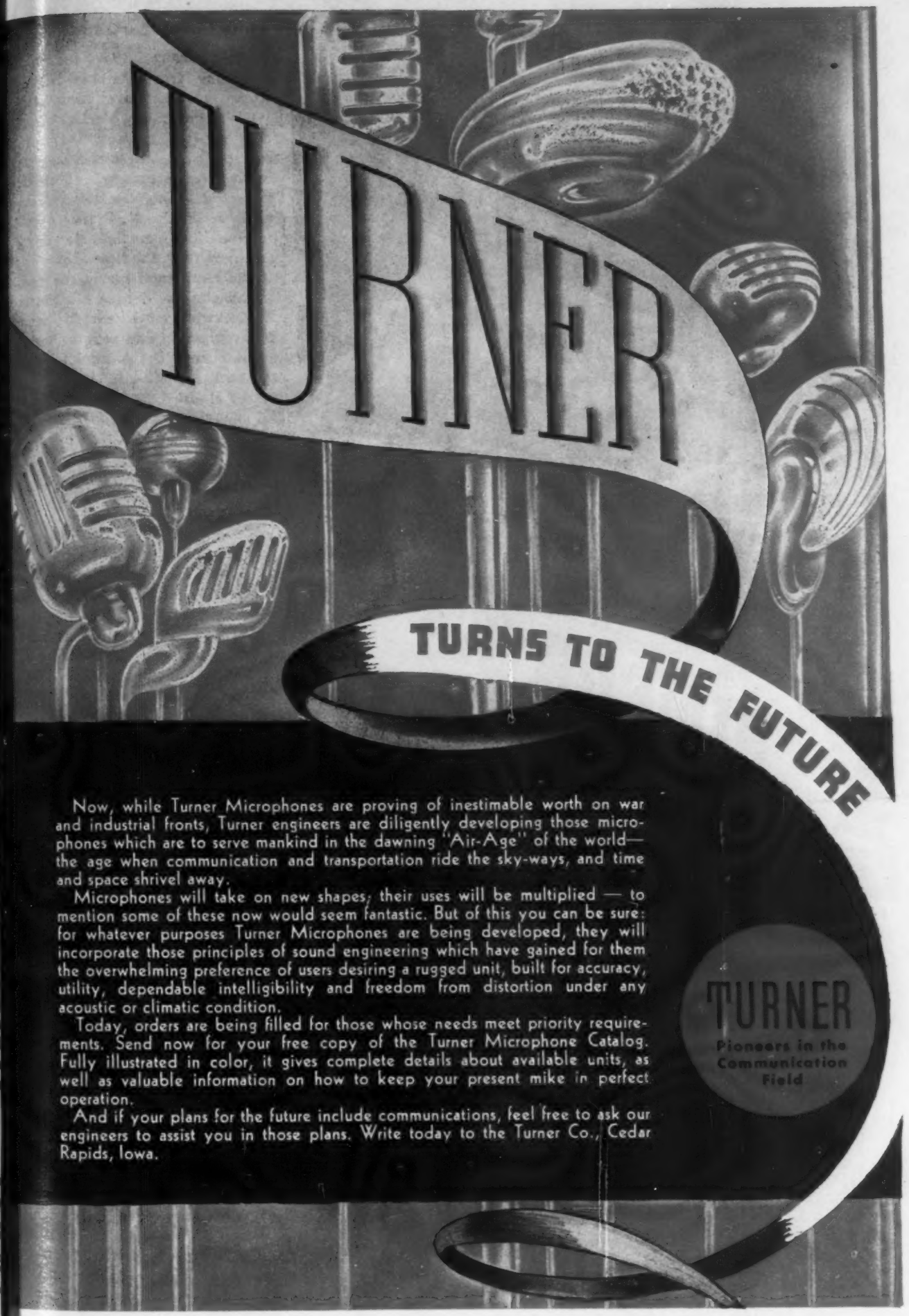
(1) C. E. Weinland, ELECTRONICS 8, p. 2 1935.
(2) RCA Bulletin PT-20R1, Dec. 1 RCA Manufacturing Co., Harrison, N. J.
(3) "International Critical Tables," 6 136, 1929, McGraw-Hill Book Co., New Y N. Y.
(4) J. C. Maxwell, "Treatise on Electri and Magnetism," Vol. I, Article 347, 3 edition, 1881. Oxford Press.
(5) J. R. Roebuck, *J. Opt. Soc. Am.* *Rev. Sci. Instr.* 3, p. 93, 1932.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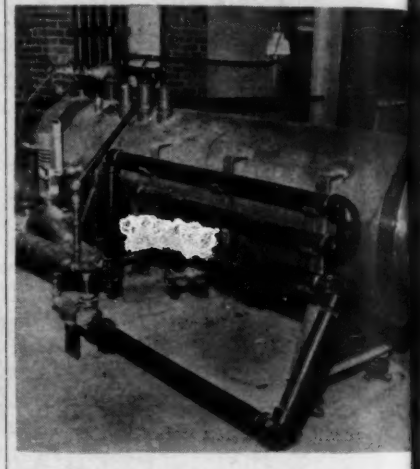
TIMING ERRORS that occur when switching from local to NBC network programs are eliminated at WOW, Omaha, by a clock-like dial hung on the glass window of the control room. The dial is calibrated in five-second intervals, both clockwise and counterclockwise, from 12 to 6. When the NBC time signal is received the operator notes any discrepancy from the time shown on the studio clocks and moves the pointer to indicate the degree of difference. A clockwise movement indicates a fast correction and counterclockwise a slow correction. A duplicate dial on the back is visible to the announcer in the studio.

• • •

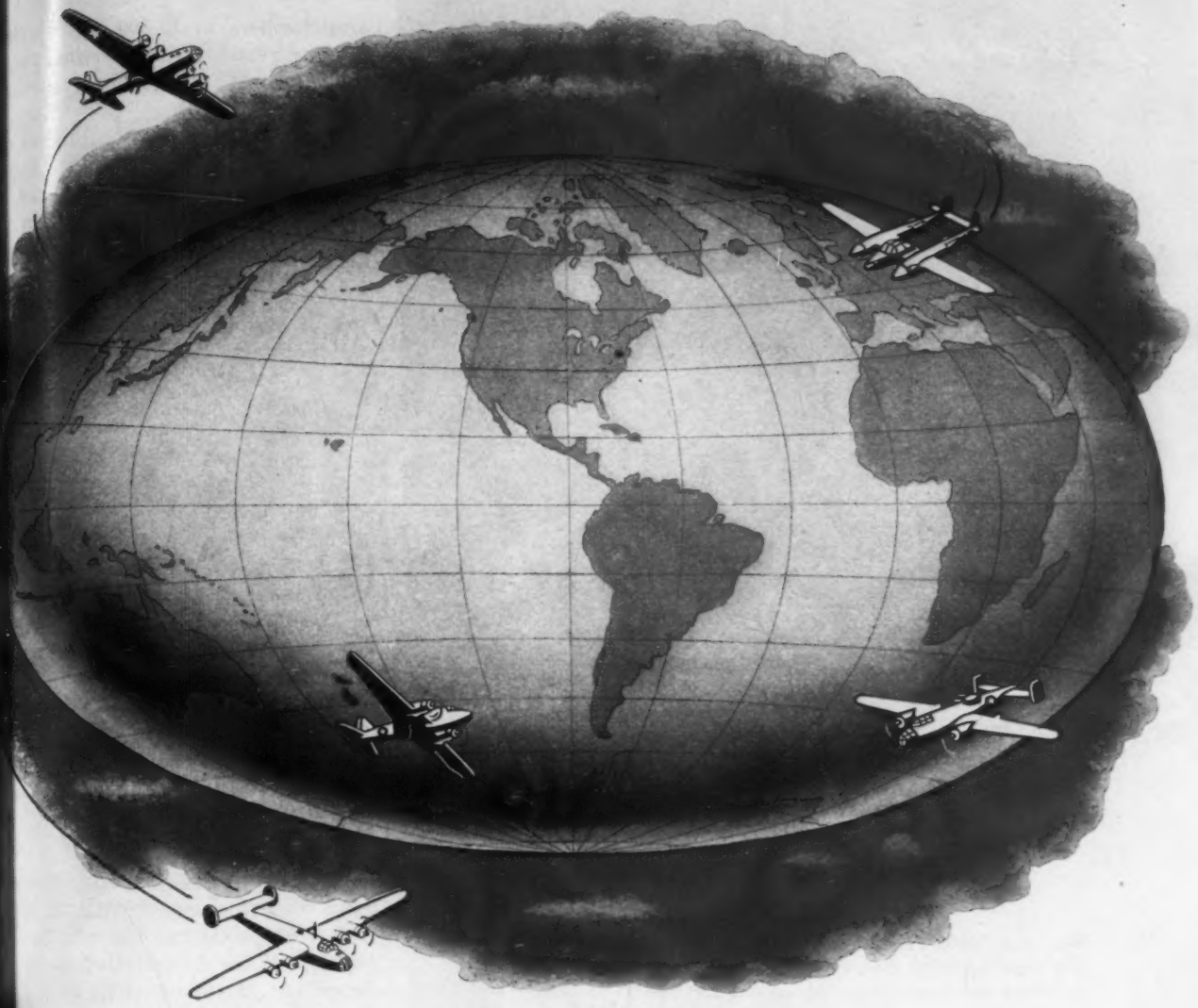
Insulating Pipe for Rectifiers

WATER-COOLED RECTIFIERS are insulated from the water supply by pipes made of saran, a thermoplastic in the Dow Magnesium Corp. plant in Michigan. The plant produces magnesium metal by the electrolytic method, and each of scores of cells must be supplied with 600 volts to electrolyze the magnesium chloride and produce molten metal.



Water-cooled rectifiers for mass production of magnesium metal are insulated from heat exchangers, shown above, by saran plastic pipe

A rectifying station housing twelve rectifiers and a similar number of heat exchangers is the center of power distribution for each cell building. Power for the plant is supplied at 120,000 volts and is stepped down by a group of outside



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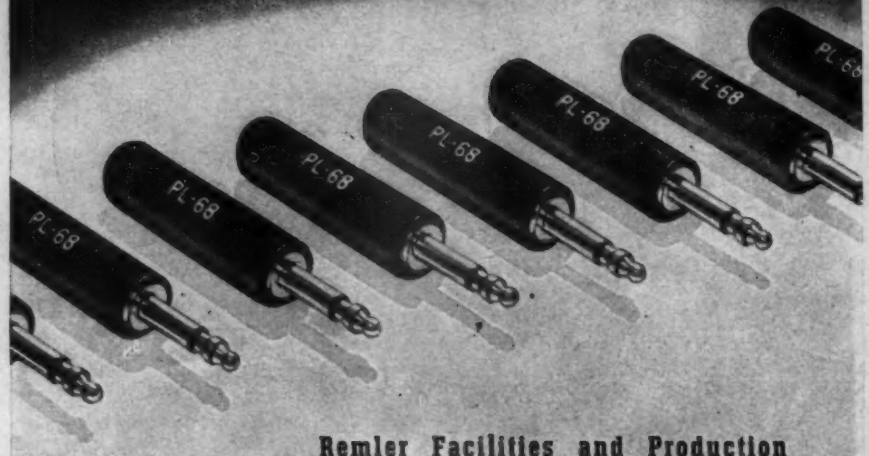

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55	63	77	120	160	60	74	60	74	60	74
56	64	104	124	354	61	76	61	76	61	76
58	65	108	125		62	77	62	77	62	77
59	67	109	127		63	104	63	104	63	104
60	68	112	149		64		64			

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transformers to 13,800 volts before feeding rectifier stations where conversion to 600 volts of direct current takes place.

Heat developed in the process of rectification is absorbed by water jackets in each rectifier unit and is carried by a circulating system to heat exchangers on the floor below by saran pipe, a product of Dow Chemical Co. The insulating properties of saran pipe prevent the 600-volt potential of the rectifier water jackets from being grounded through the heat exchangers to the water system.

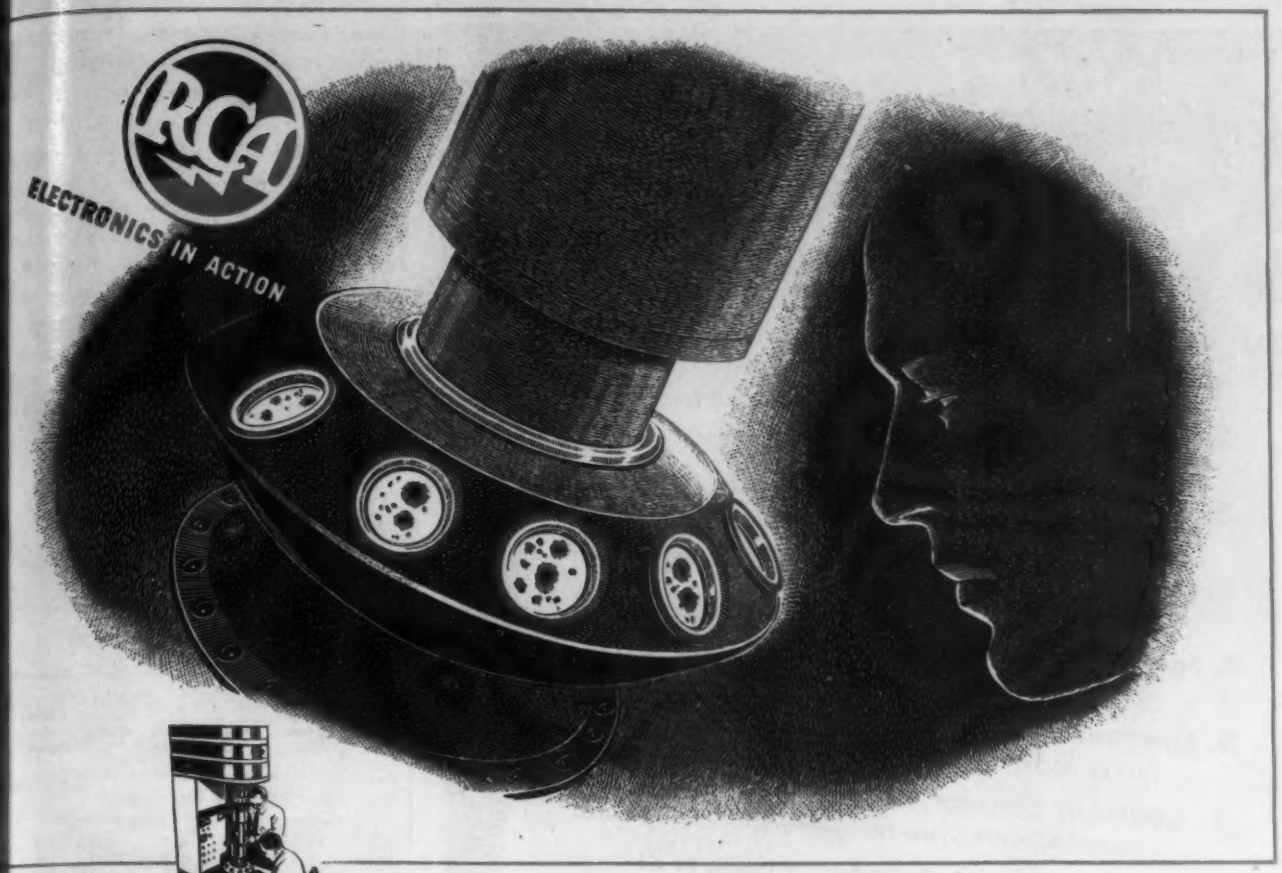
When the magnesium cells are in operation heavy leakage currents may travel to ground through the walls of the building. To prevent this loss a layer of 1/16 inch thick saran sheet was placed between the bricks of the walls, about six feet above ground, and between the metal joints and beams in the building during construction.

• • •

Selenium Rectifiers for Tin Plating

ONLY MEAGRE STOCKS of tin were on hand when the enemy obtained control of 80 percent of the world's tin supply, but the electrolytic method of deposition of tin on strip steel has helped conserve the dwindling supply. This method, which had been developing slowly for five years before the war, uses only about one third the amount of tin required by other methods and permits control over the thickness of the coating. High values of direct current, ranging up to 50,000 amperes, are necessary for the electrolytic method. These currents can be obtained from selenium rectifiers, according to a story in Vol. 21, No. 2 of *Electrical Communication.*

About 26 continuous strip mills are being installed as part of the tin conservation program. In these, the process is continuous with the strip operating at from 250 to 650 feet per minute. At the latter speed each line requires aproximately 48,000 to 60,000 amperes of direct current. Selenium rectifiers for nine of the 26 lines are being built by Federal Telegraph & Radio Corp., and consist of eighteen 7500-ampere units, three 5,000-ampere units and three 3,000-ampere units, making a total of 189-



Exploring A New Universe

THROUGH those small round windows—observation ports of an RCA Electron Microscope—this bacteriologist is studying influenza virus—magnified 35,000 times!

For years medical research men have had to fight the devastation of influenza "blindfolded" — for the simple reason that flu germs are invisible even under the most powerful light microscope. *But why invisible?* Why couldn't this virus be seen? The answer is—even the shortest waves of visible light are *far too long* to permit seeing anything so small. Nothing so infinitesimal ever was seen—or could be seen—prior to invention of the Electron Microscope.

But man *needs* to see these smaller things—among which are long-hidden causes of many diseases destructive to human beings, animals and plants. Man *needs* to be able to peer down, down, down into molecular structures—in order to learn what makes rubber behave like rubber, leather like leather, wool like wool, lubricating oil like lubricating oil, or metal like metal. For under the whiplash of war it is imperative to learn now, not tomorrow, *why* one kind of rubber, leather, fiber, oil or metal is more elastic, tougher, stronger, more useful than another.

Every branch of science and industry can benefit through proper use of this extraordinary microscope—which utilizes electrons instead of light for illumination. The RCA Electron Microscope is only one of many RCA applications of *electronics*—the art of harnessing electrons to the service of man. *Every* electronic device of *every* kind depends basically on electron tubes. And RCA is the fountain-head of modern electron tube development.

In addition to our armed forces, the list of industrial firms and scientific institutions now using RCA Electron Microscopes reads like a Blue Book of American Industry and Science. Inquiries regarding this instrument will be welcomed from research men connected with similar organizations, and will be promptly answered. Address Department 131-765, RCA Victor Division, Radio Corporation of America, Camden, N. J.

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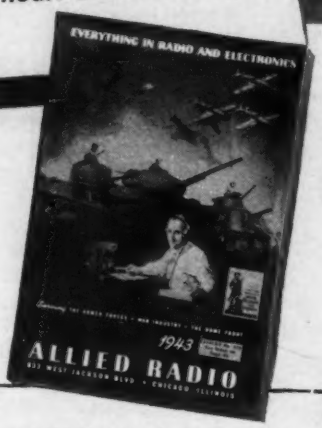

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000 amperes at 12 volts. Output voltage of the units is controlled by saturable-core reactors that permit a variation from 0.75 volts to 12 volts.

The rectifier units have their selenium plates immersed in a liquid that absorbs heat and protects the plates from moisture and corrosive fumes. This permits locating the rectifiers near the plating tanks and reduces the amount of copper necessary for the installation. Further savings of copper over other means of converting a-c to d-c are effected because of the small copper content of the rectifiers.

• • •

Classification Chart of RCA Cathode-Ray Tubes

Type No.	Screen Diam. (in.)	Fluorescence	Heater Volts	Max. Volts on Anode No. 2	Deflection Factor†
Electrostatic Deflection Types					
913	1	Green	6.3	550	598
2AP1	2	Green	6.3	1100	230
902	2	Green	6.3	660	230
3AP1	3	Green	2.5	1650	76
3AP4	3	White	2.5	1650	76
3BP1	3	Green	6.3	2200	110.5
3EP1	3	Green	6.3	2200	110.5
5AP4	5	White	6.3	2200	74.7
5BP1	5	Green	6.3	2200	42.4
5BP4	5	White	6.3	2200	42.4
5CP1	5	Green	6.3	2200	‡46
5CP4	5	White	6.3	2200	‡46
5HP1	5	Green	6.3	2200	42.4
5HP4	5	White	6.3	2200	42.4
905	5	Green	2.5	2200	57.5
914	9	Green	2.5	7700	40
908*	3	Bluish	2.5	1650	76
907*	5	Bluish	2.5	2200	57.5
Electrostatic-Magnetic Deflection Types					
904	5	Green	2.5	5060	63.5
9JP1	9	Green	2.5	5500	37.5
Magnetic Deflection Types					
7AP4	7	White	2.5	3850	....
7CP1	7	Green	6.3	7700	....
9AP4	9	White	2.5	7700	....
12AP4	12	White	2.5	7700	....

Iconoscopes

Type No.	Mosaic size inches	Heater Voltage	Maximum Anode Volts	Use
1847	1 1/16 dia.	6.3	660	amateur
1848	2 1/4 x 3	6.3	1320	portable camera
1849	3 5/16 x 4 1/4	6.3	1320	film pickup
1850	3 5/16 x 4 1/4	6.3	1320	studio pickup

Orthicons

1840	1 3/4 x 2 1/16	6.3	330	film and studio pickup

* Short-persistence screen. All others have medium persistence.
† Rated at an anode No. 2 potential of one kilovolt for all types to permit comparison. Actual deflection values may be obtained by multiplying the deflection factor given above by the operating anode No. 2 voltage in kilovolts.
‡ On basis of a 2 to one ratio between voltages of anode No. 3 and anode No. 2.

Can you use this

new — .0004" — flexible material?

In developing and manufacturing entirely new Electro-Voice Microphones our engineers have had to experiment in nearly all branches of the scientific arts. About a year ago, one important microphone project was delayed because a thin and extremely flexible sheeting material was not available commercially.

Although we aren't chemists, we finally developed, what we believe to be, another Electro-Voice "first" . . . a method of sheeting a flexible material to as thin as four ten-thousandths of an inch. It is a material that can be stabilized, and one that will retain all of its characteristics from —40°F. to +185°F.

We design and manufacture microphones . . . have been doing it for the past 16 years . . . and we intend to stick to our own field. However, if you're in war production and can use this new material, we'll be glad to save you the time and trouble of developing it yourself. Just tell us how much you need. . . we'll fill your order.

Blood donors are needed immediately . . . . see your local Red Cross

Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC. • 1239 SOUTH BEND AVENUE • SOUTH BEND, INDIANA

Export Division: 13 East 40th Street, New York 16, N. Y. — U. S. A. Cables: ARLAB

Coordination of effort in building airplanes... in flying them over the skyways, and in landing them at the airports of the world is the secret of the fine record for safe flights made by PAN-AMERICAN airways.

By the same token, the use of only the finest quality parts in building every plane and in constructing the mechanisms which direct its comings and goings, is another very important factor in promulgating complete safety.

That is why Thordarson transformers were selected by PAN-AMERICAN airways for important uses in the planes themselves as well as for use in control tower operations, where dependability and quality of material are of such great importance.

ARMY E NAVY

THORDARSON

ELECTRIC MFG. COMPANY
500 W. HURON ST., CHICAGO, ILL.

Transformer Specialists Since 1895

ORIGINATORS OF TRU-FIDELITY AMPLIFIERS

Microwave Plumbing

(*Continued from page* 121)

a double stub. The single-tube model in Fig. 20 very successfully combines the advantages of coaxial and parallel lines. The double-ended parallel line tank circuit is tuned by worm-driven pistons within the cylindrical covers. The entire outside surface is grounded, leaving only the filament leads at high potential. Two coaxial cables have their inner conductors coupled to the plate and grid sides of the tank respectively. Together they form a shielded output line which is suitable for coupling to center-driven antenna loads without detectable currents on the outside surface of the oscillator. A variable-length section on one of the cables adjusts the phases of the currents to be opposite where connection is made to the parallel line.

Finally, at 10 cm, klystron oscillators are used. The last illustration shows a rear view of a complete klystron installation in a movable cabinet.

REFERENCES

(1) King R. and Blake, Jr., F. G., The Self-Impedance of a Symmetrical Antenna, *Proc. I. R. E.*, **30**, p. 335, July 1942.
(2) King, R., Coupled Antennas and Transmission Lines, accepted for publication in *Proc. I. R. E.*

• • •

Registry Control

(*Continued from page* 99)

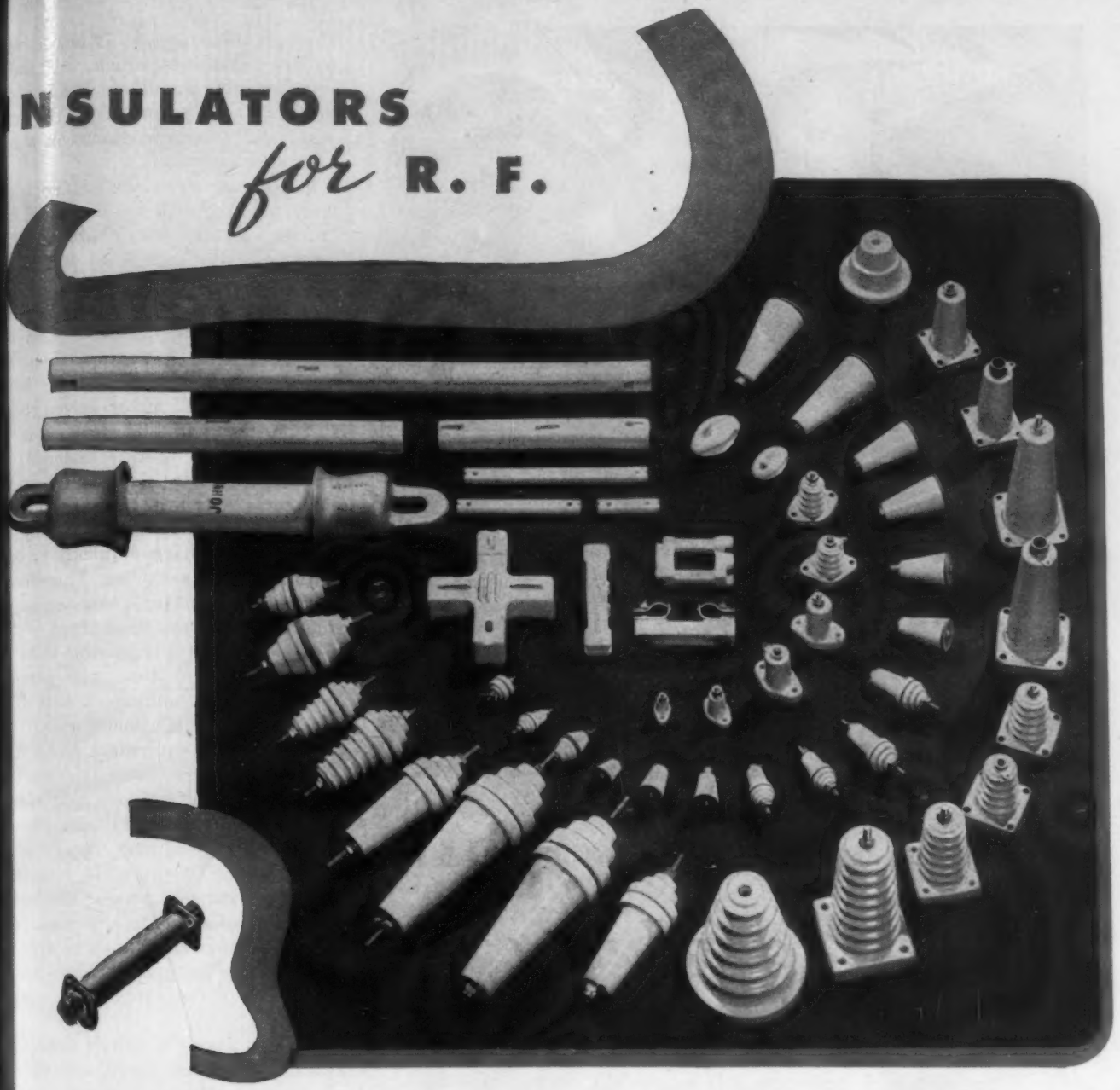
realized, however, that as the speed of operation and the accuracy required become more critical, there is added responsibility on the part of the packaging-machine maker to produce a machine that will hold a fairly constant tension and which will be free from excessive backlash.

All-Electronic Controls

An almost exact electronic equivalent of the magnetic type of space and speed control has been used on some jobs requiring high accuracy at extreme operating speed (1/64-inch at 400 fpm).

A disk having accurately-cut slits is used in place of the mechanical cam on the contact-type rotary selector switch. Light is projected

INSULATORS *for* R. F.



Many commonly used insulating materials function perfectly in low frequency circuits such as audio, 60 cycle power or even the lower radio frequencies. These same materials at medium or high radio frequencies act as high resistances to waste precious R. F. Many porcelains, steatites, glasses and similar materials have this fault and only tests under laboratory conditions will detect it. Johnson insulators were not only designed for high R. F. but the materials were selected only after exhaustive tests to determine the best. Can you afford to take chances? Demand the best—they cost no more—specify Johnson.

Ask for CATALOG 967D

JOHNSON

a famous name in Radio

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through these slits so it is received by two phototubes, which, with their accompanying amplifiers, act in very much the same manner as the forward and reverse contacts on a rotary selector switch.

The signals from the web register mark and the disk are compared by "mixer" tubes, which are usually pentodes using both No. 1 and No. 3 grids for control. The field of the correcting generator is supplied by power tubes that operate in parallel. The element that permits a comparatively constant speed to be held (equivalent to the motor-driven rheostat in the magnetic device) is a large capacitor that is charged or discharged quite slowly. A space change is obtained from a smaller capacitor in series, one which may be charged or discharged quickly by the output of the mixer tubes. Therefore, if given sufficient time, even the large capacitor is always discharged to its initial state, and it is possible to have a preset control that will permit starting of the equipment with the optimum generator field current.

This type of equipment has some advantages where the register marks are spaced comparatively far apart (24 inches or greater) and where the machine speed may vary over a wide range. However, it has the same requirements as the magnetic space and speed control, in that the differential generator must be driven from the packaging machine itself and d-c must be supplied for field excitation.

For equipment which is operated at a more uniform speed, and where register marks are spaced fairly close together (less than 4 inches apart), a newer type of all-electronic register control offers a number of advantages. The control makes use of a high-speed d-c exciter, called an "amplidyne". This permits extremely fast response and high accuracy, and eliminates the need for a machine-driven generator. Since amplidyne fields require only a fraction of the power required for the conventional generator, a smaller and less expensive control panel can be used.

—◇—

OVER 20,000 short-wave radio receivers are now being used by our armed forces overseas for entertainment purposes, along with about 500,000 phonograph records.

"See! . . . I told you! Music right out of the air!"

IN THOSE DAYS YOU DIDN'T CALL IT

"Electronics"

. . . but the first portable radio was just as amazing in its time as the electronic wonders that are helping win the war today . . . and will help *you* win business battles tomorrow! When you need help on electronic applications to your product or process, remember Operadio built the first commercial portable radio, was head-over-heels in engineering and practical manufacturing *years before* most people even heard the word "electronics!" Operadio has been continuously developing electronic products for other industries. At Operadio it's war work today . . . *your* electronic problem tomorrow!

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Electronic Specialists

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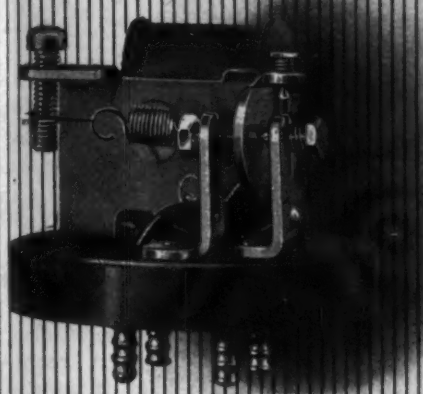
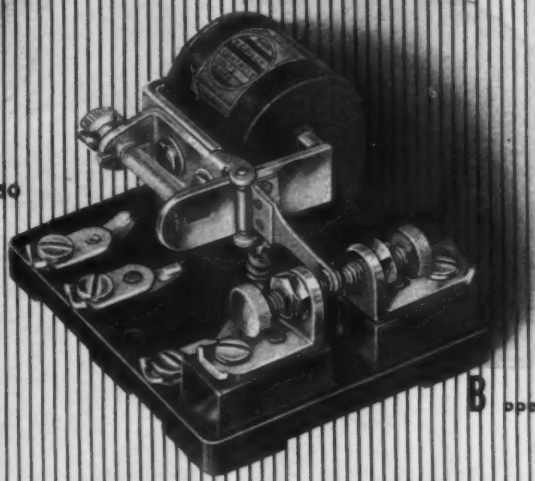


G operating wattage 0.050



B operating wattage 0.012

Sensitive and Close Differential RELAYS

Ruggedness and Sensitivity are built into Allied's B and G Sensitive and Close Differential Relays. These essential factors, Stamina and Lightning Response, enable B and G Relays to withstand the grueling punishment of use in air, sea and land equipment.

B Relays have precision bearings with stainless steel shafts. G Relays have watch type pivoted bearings. These exclusive features keep operating friction to a minimum.

B and G Relays are designed to meet Army, Navy and CAA specifications . . . shock and vibration . . . temperature . . . humidity . . . salt spray . . . etc.

OPERATING CHARACTERISTICS

B and G Sensitive and Close Differential Relays are made in Single Pole Single Throw, Normally Open . . . Single Pole Single Throw, Normally Closed . . . and . . . Single Pole Double Throw.

Dimensions: G-1 7/8 x 1 7/16 in.
B-2 3/8 x 2 3/4 x 1 3/4 in.

Weights: G-3 1/2 ounces
B-7 ounces

ALLIED CONTROL COMPANY
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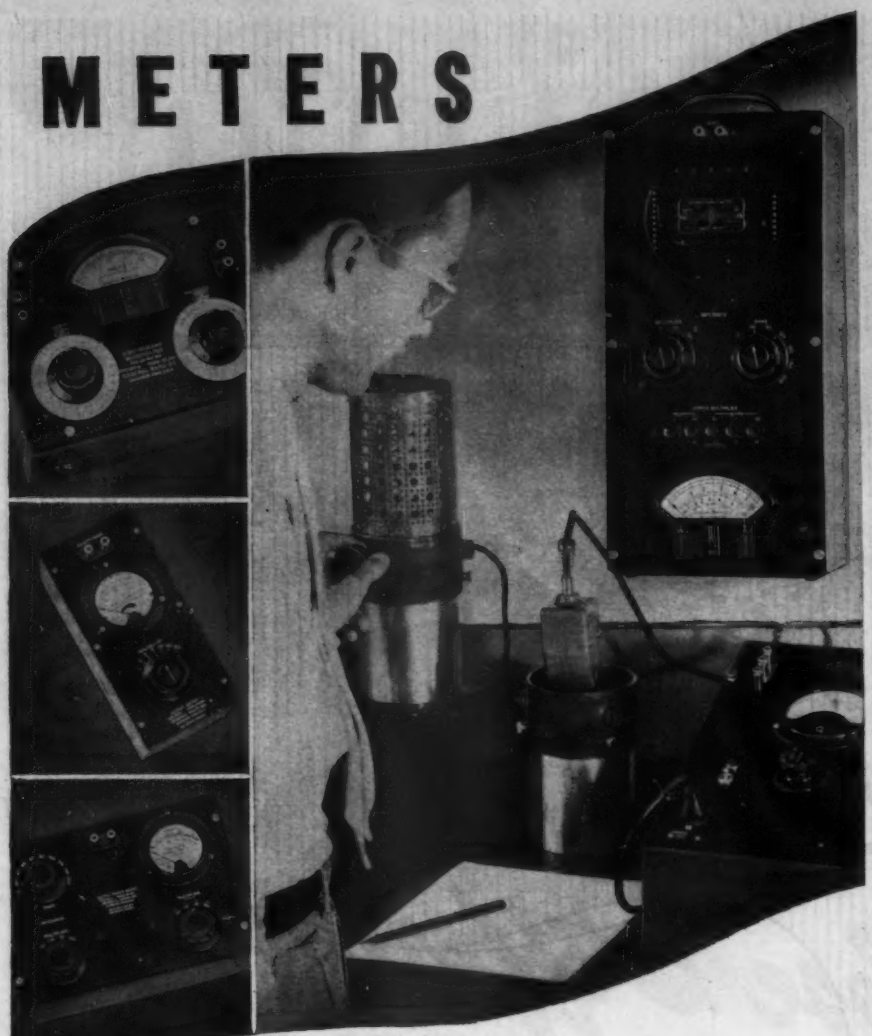
METERS



for the COMMUNICATIONS ENGINEER

Quantitative measurements of the performance of electrical circuits depend upon instruments for the measurement of voltage, current and power. Limited-range, single-frequency instruments are adequate at power frequencies, but measurements at communication frequencies require specialized types covering wide ranges of frequency and voltage.

Since 1915, the General Radio Company has been building these special-purpose meters for the communications industry. The present line includes both copper-oxide and vacuum-tube types covering a frequency range from d-c to ultra-high radio frequencies, and a voltage range from 50 millivolts to 300 volts.

In war time as well as in peace, the leading communication laboratories are equipped with General Radio instruments, backed by 28 years of experience in designing and building high-quality apparatus.

Because all our facilities are devoted to war projects, these meters are at present available only for war work.

ARMY E NAVY

GR **GENERAL RADIO COMPANY**
Cambridge 39, Massachusetts
NEW YORK 6 LOS ANGELES 38

Moving WJZ

(*Continued from page* 101)

the necessary 2400-volt power line with duplicate power facilities if possible and with telephone lines and water mains nearby. This meant a site near a town, yet many of the communities in northern New Jersey are now zoned for residential purposes only.

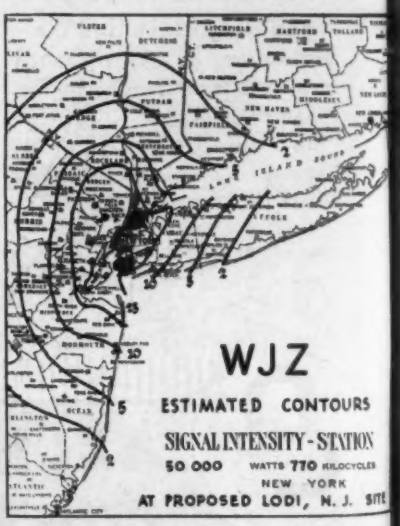
Proximity to airports also had to be considered. CAA requirements specify a lane 2500 ft wide at a distance of two miles from the airport for manual landing and a lane 400 ft wide for instrument landing with no transmitting towers permitted in existing or proposed lanes.

The time element was also important, with the move scheduled for completion by the end of this year so that the short-wave transmitters could be placed in operation as soon as possible after they were built.

Advantages of Final Site

The final decision went to a site near the town of Lodi, New Jersey. This site was far enough away from other stations to prevent serious re-radiation, and did not require too great a transmission angle through Manhattan to Brooklyn. It had the 2400-volt power line only one block away, with city water mains one block away and telephone lines two blocks away. All other factors were equally favorable for present needs.

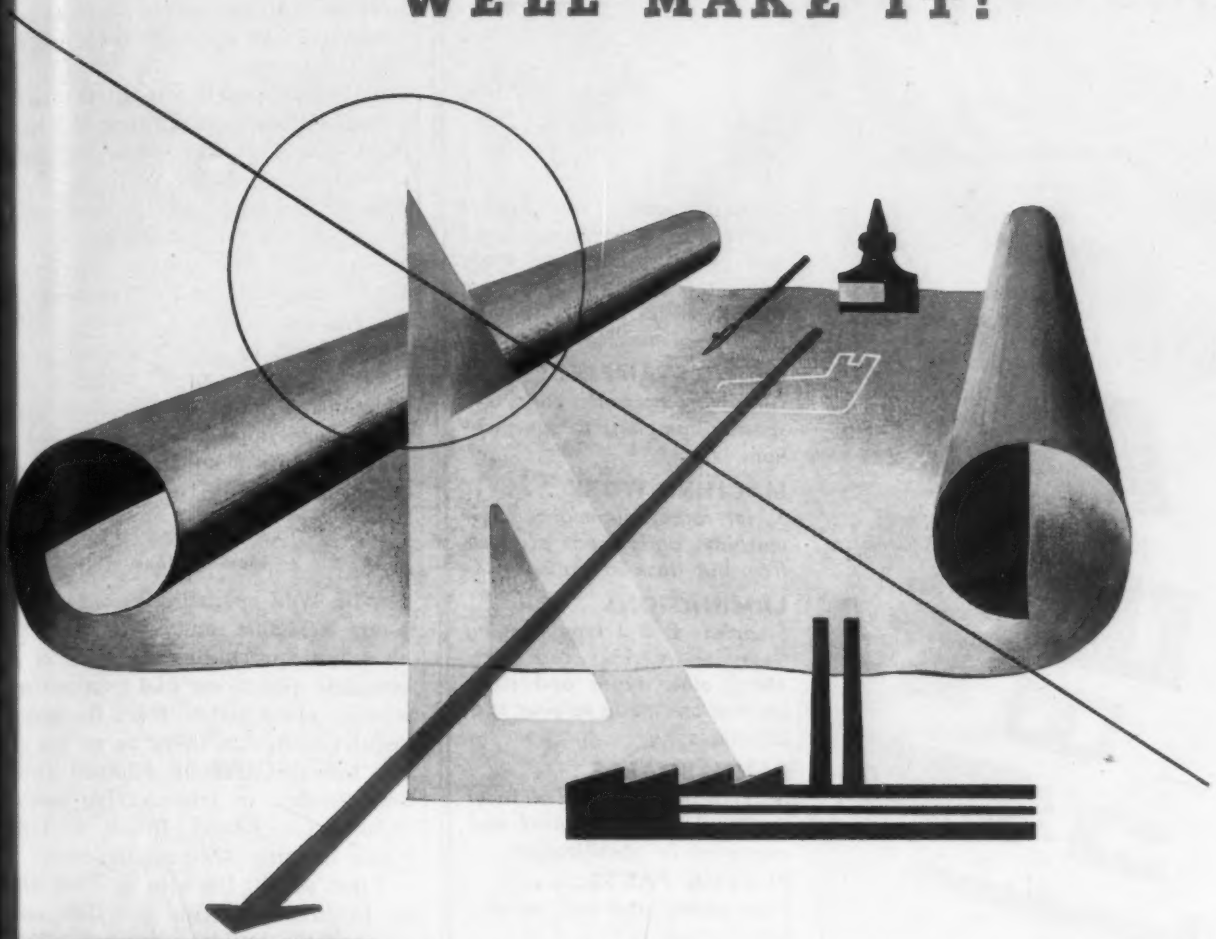
With the WJZ transmitter at Bound Brook, an estimated half-million people were within the 50-mil

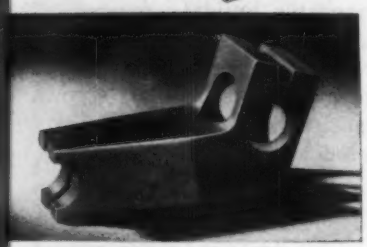


New York City will get better than 2 millivolts when WJZ is in its new location

YOU DESIGN IT...

WE'LL MAKE IT!





f you think of Phenol Fibre as a plastic that can be ed only for the simpler types of insulation, look at is high-finished radio slider that is drilled, slotted, nd beveled into just about as complicated a piece f equipment as you'll find in any electrical device. aylor ingenuity and Taylor equipment turn out such ieces by the thousands at remarkably low cost. efore you decide "it can't be done," Take it to Taylor.

There are, of course, certain limitations as to what can be made of Vulcanized or Phenol Fibre. *But those limitations are probably much less than you think!* If you are now wrestling with a problem that calls for speedy production of a strong, tough, lightweight, economical part with high dielectric strength, resistance to extreme temperatures and to chemical action, Take it to Taylor.

In the industry's most modern plant, straightline production, from the manufacture or processing of the raw materials to the finished product itself, assures production-economies and quality-control that result in many a modern manufacturing miracle. This Verifibre Process, in which Taylor Fibre is checked and verified at every step in production, produces a product of dependable and uniform quality.

With your blueprints before us, we can tell you in a jiffy how we can help you. Let's talk it over.

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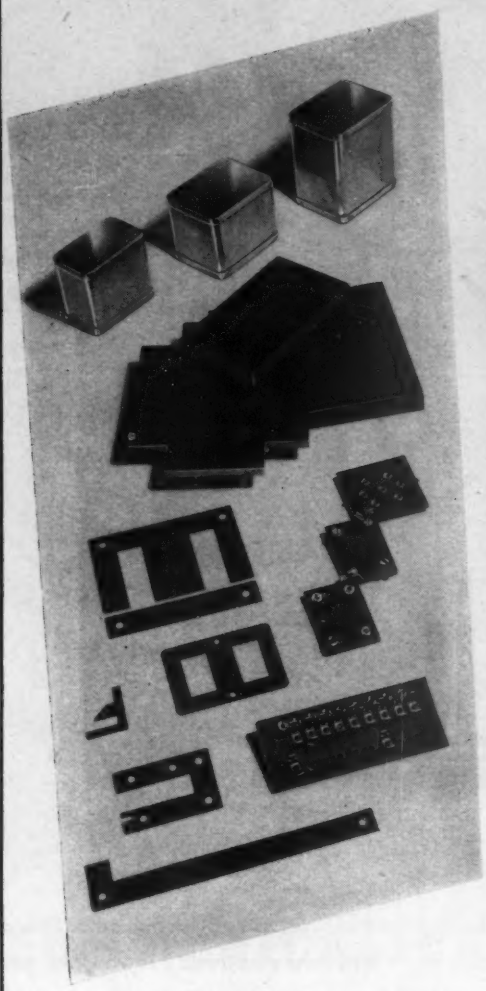

Housed within four daylit floors is a modernly equipped tool and die shop, and every facility for fabrication from raw stock to shining finished product of such items as:

METAL STAMPINGS . . .
Chassis, radio parts, cans, and special stampings to specifications

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Scrapless E & I type ranging from ½" to 1¾" core size. Many other types and sizes. Laminations made to your specifications

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From sheets and rods to any specification

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volt signal strength contour. At Lodi, it is estimated that this same contour will include approximately eight million people, with other contours showing equally favorable increases. (Measured old contours and estimated new contours are shown on the front cover.)

Although practically all the large broadcast stations serving the New York City area have improved their coverage by moving their transmitters to new sites and by increasing power during the last ten years, WJZ remained 35 miles outside the city all that time awaiting FCC approval of its request to use a 500-kw transmitter built by RCA. Future prospects for such power being rather nebulous, a move to a close-in location more appropriate to a 50-kw station offers a substantial increase in signal strength with the present power.

Moving Plans

With WJZ operating on a 24-hour-a-day schedule and with wartime shortages precluding erection of a complete new tower and transmitter, moving plans had to meet the prime requirement that there be no loss of air time. Carefully planned steps are involved in transferring operations from Bound Brook to Lodi while meeting this requirement.

First of all, the site at Lodi will be prepared and the complete new transmitter building erected. This will be of modern single-story design.

Secondly, the 50-kw broadcast transmitter at Bound Brook will be connected to its present auxiliary antenna, permitting dismantling of

• • •

"OSCAR" LEARNS RADIO

Sgt. Verlin C. Blackwell, of Miami, Fla. sends out a message from a South Pacific base while "Oscar" a pet wallaby listens to the reply coming from the speaker above his head

A *TUBE* made this possible!

You are looking at an after-war scene made possible by a *tube* . . . a 15 inch Cathode ray tube! For within this high powered "heart and brain" of television is marshalled the electronic energy which has already thrilled theatre audiences with televised projections on full size (15 *foot* x 20 *foot*) theatre screens. We can look forward to these coming events which would even now be in full swing but for the more serious obligations of Science to National War Emergency. Today, all of RAULAND engineering resources are at work for our war effort but RAULAND sights are set ahead to serve industry in the new days to come.

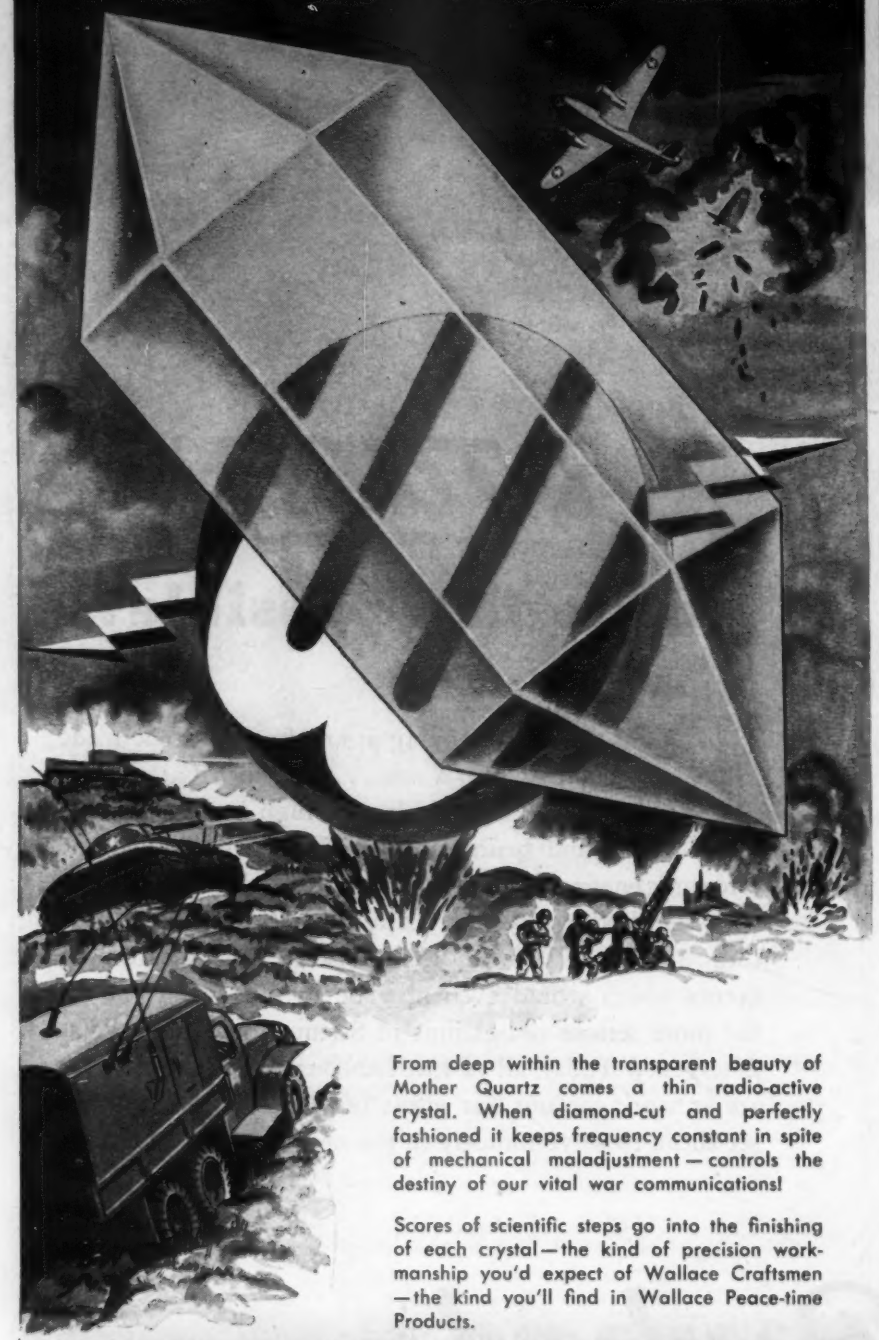
RADIO . . . SOUND . . . **Rauland** . . . COMMUNICATIONS

Electroneering is our business

THE RAULAND CORPORATION . . . CHICAGO, ILLINOIS

Buy War Bonds and Stamps! Rauland employees are still investing 10% of their salaries in War Bonds

DESTINY *in a Rock*



From deep within the transparent beauty of Mother Quartz comes a thin radio-active crystal. When diamond-cut and perfectly fashioned it keeps frequency constant in spite of mechanical maladjustment — controls the destiny of our vital war communications!

Scores of scientific steps go into the finishing of each crystal — the kind of precision workmanship you'd expect of Wallace Craftsmen — the kind you'll find in Wallace Peace-time Products.

Wm. T. WALLACE MFG. CO.

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the 640-ft vertical steel radiator and re-erection at the new site. The old ground system will have to be dug up and moved also because new copper ribbon cannot be obtained.

Third, the 25-kw auxiliary oscillator and r-f amplifier maintained at Bound Brook for emergency purposes will be moved to Lodi and connected to a 10-kw modulator and rectifier to be removed from the Empire State television station. New construction involved has been kept at the bare minimum essential for satisfactory operation of a 10-kw auxiliary transmitter at Lodi during the time the main 50-kw transmitter is being moved. (At Bound Brook emergency operation of the auxiliary transmitter was obtained by shutting down one of the short-wave transmitters at the site and using its rectifier and modulator in connection with the auxiliary r-f amplifier and oscillator. The short-wave equipment is now in continuous use and hence could not be moved.)

When the 10-kw job is completed at Lodi and connected to the 640-foot tower and to program lines, WJZ will begin broadcasting from Lodi at the reduced power of 10 kilowatts.

Finally, the existing 50-kw broadcast transmitter at Bound Brook will be moved to Lodi, installed in the new building and connected to its original 640-ft tower. This will complete the moving job and place WJZ on the air again with its normal 50-kw power.—J. M.

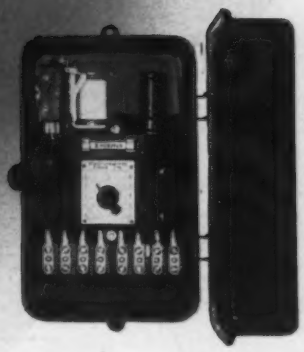
• • •

RADIO LANDING FOR PLANES

This mobile airport radio equipment of the Civil Aeronautics Administration is in use at airports to provide a safe, sure landing of planes

THROUGH THE MIRACLE OF ELECTRONICS

PHOTOSWITCH provides modern industry with more than 50 types of electronic CONTROLS for . . .



TIMING

Photoswitch Timers are universal for time delay and interval timing from .05 sec. to two minutes. Extensively used on Injection Moulding Machines, X-Ray Apparatus, Automatic Spraying Equipment, Process Control, Automatic Machine Tools, Welding Equipment, Embossing Presses, Automatic Ship Whistle Control, etc. Electronic operation eliminates moving parts, friction, wear — guarantees unlimited-life accuracy. Reference Bulletin 901A.

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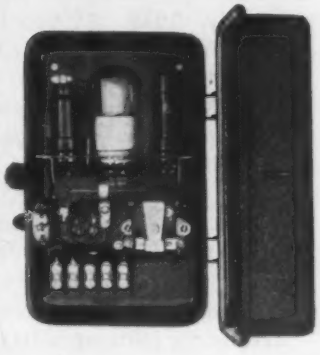
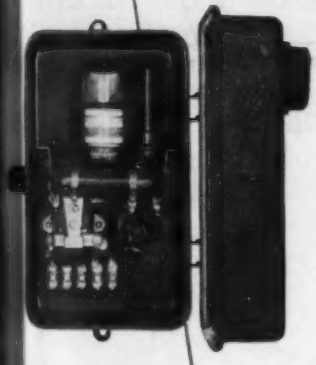
...toswitch Level Controls are ...ndard equipment on pumps, ...s, stills, refrigerating systems, ... — control level of any liquid ... powder) electronically. Control ...floatless — only metal probe ...tacts material. Liquid itself, as ...makes or breaks contact with ...e tip, actuates electronic con... relay — automatically operates ...als, valves, pumps. Reference ...letin 1100.

TURBIDITY

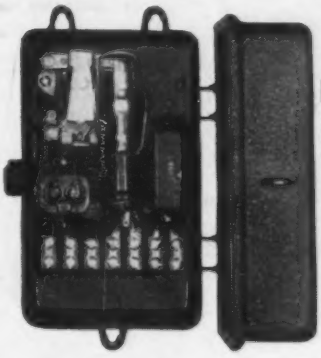


Photoswitch Controls are adaptable to practically all turbidity problems (even when transparency is very low) — actually "see" through liquids, reporting minute turbidity changes invisible to human eye. Densometer in control circuit gives continuous meter indication of turbidity change. Sensitivity adjustment on control may be set so that relay will flash signal, sound alarm, operate valves or pumps — at any predetermined degree of turbidity. Reference Bulletin 315.



ELECTRIC EYE

Photoswitch Type A15 is one of a wide variety of photoelectric controls available for hundreds of machinery applications. Beam of light is projected across conveyor, bed of machine, or any area to be controlled, to the photoelectric control. Objects breaking beam actuate relay — operating electrical counter, machinery safeguard, stop motion mechanism, etc. Reference Bulletins 310 and 312.

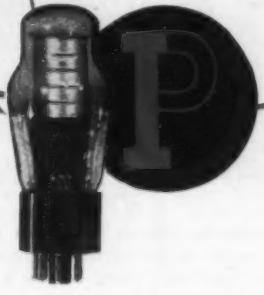


PILOT RELAY

Photoswitch Pilot Relays make possible the control of large currents by delicate mechanisms, or extremely light contact pressure. Used on textile looms, warpers and winders — also on paper processing equipment for stop motion control on break detection. Monitors feed, keeps production count, on automatic punch presses — also used as limit switch on machine tools. Reference Bulletin 900A.

...te for Special Bulletins describing any or ... of the Photoswitch Controls illustrated.

PHOTOSWITCH Photoelectric and Electronic Controls provide completely automatic machine operation, release needed manpower, speed war production — can be incorporated in the design of any electrically operated machine, or can be quickly and easily installed on machinery already in operation. The engineering staff of Photoswitch Incorporated will welcome the opportunity to assist in the solution of your automatic control problems. Write today for further details on standard PHOTOSWITCH equipment, or for recommendations on how PHOTOSWITCH controls can be adapted to meet your specific requirements.



PHOTOSWITCH INCORPORATED

PHOTOELECTRIC & ELECTRONIC CONTROLS FOR EVERY INDUSTRIAL PURPOSE

CAMBRIDGE, MASS. • *District Offices* IN ALL PRINCIPAL CITIES

THE ELECTRON ART

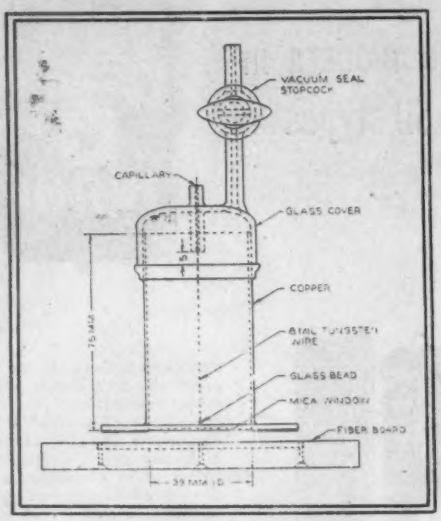
Geiger Counter Tube for Soft Radiations.....190
Elongation Recorders for Single Textile Fibers.....192
New Signal Converter Tubes for Television Circuits.....198
Velocity of Radio Waves.....206

Geiger Counter Tube for Soft Radiations

A MICA-WINDOW GEIGER counter tube, which combines the speed of a metal-walled tube with a sensitivity to soft radiations comparable to that of screen-walled tubes, is described by D. H. Copp and D. M. Greenberg in the *Review of Scientific Instruments* for July, 1943. It consists of a treated metal cylinder covered at one end by a thin sheet of mica and at the other end by a glass bell with a central capillary. Through this capillary is sealed a piece of 8-mil tungsten wire with a drop of glass fused over the end. The tube is operated at a pressure of 10 cm of mercury with a mixture of 10-percent ethanol and 90-percent argon.

Artificially induced radioactive isotopes are usually determined with an electroscope, electrometer, or glass or metal-walled Geiger counter tube. Unfortunately the radioactive isotopes of some of the important biological elements, such as Na^{22}, S^{35}, Ca^{45}, and Fe^{55}, have radiations which are too soft to penetrate the metal or glass walls of such counters. To measure such weak radiations a screen-walled counter has been devised by Libby and his associates.[1] Since each sample must be mounted inside the tube, and the tube evacuated and filled with an appropriate gas mixture before the radioactivity may be determined, the method is very time-consuming and a serious disadvantage in measurement of a large number of samples.

To overcome this disadvantage a counter with a mica window was adapted from that designed by R. W. Dodson of the California Institute of Technology. Very thin mica windows, which absorb only part of the soft radiations, still have sufficient tensile strength to maintain the low pressure employed within the counter tube. For example, of the soft radiation of Fe^{55}, 55 percent penetrates a mica window of 0.01 mm, 30 percent penetrates a mica window of 0.02 mm, while only two percent penetrates the thinnest metal walls of 0.1 mm thickness.



Construction of mica-window Geiger counter tube for soft radiations. The diameter of the metal flange at the bottom of the tube is 75 mm and the fiber ring is 12 cm in diameter and 1 cm thick

Construction of the Tube

The tube consists of a metal cylinder with a broad metal flange at one end to which the mica window is sealed. The other end of the cylinder is closed by a glass bell with a vacuum seal stopcock and a central capillary. Through this capillary is sealed a straight piece of 8-mil tungsten wire, which extends almost to the mica window but does not touch it. A small drop of glass is fused over the end of this wire so that the tube will not act as a point counter.

The metal cylinder may be made of brass, steel, or copper. Best results were obtained with copper tubes which received a special treatment with NO_2, described in detail in the paper. Sheets of high-grade mica were split with a fine needle having a drop of water around it for the window. For a tube of the size shown in the illustration, mica of about 0.02 mm thickness and weighing about 5 mg per sq cm has been found satisfactory. With smaller tubes even

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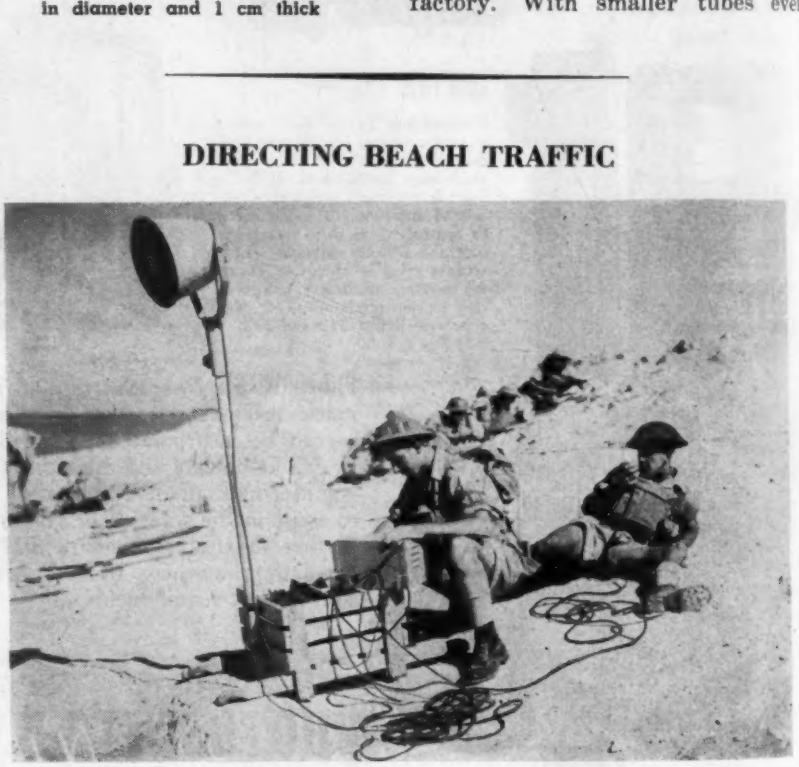

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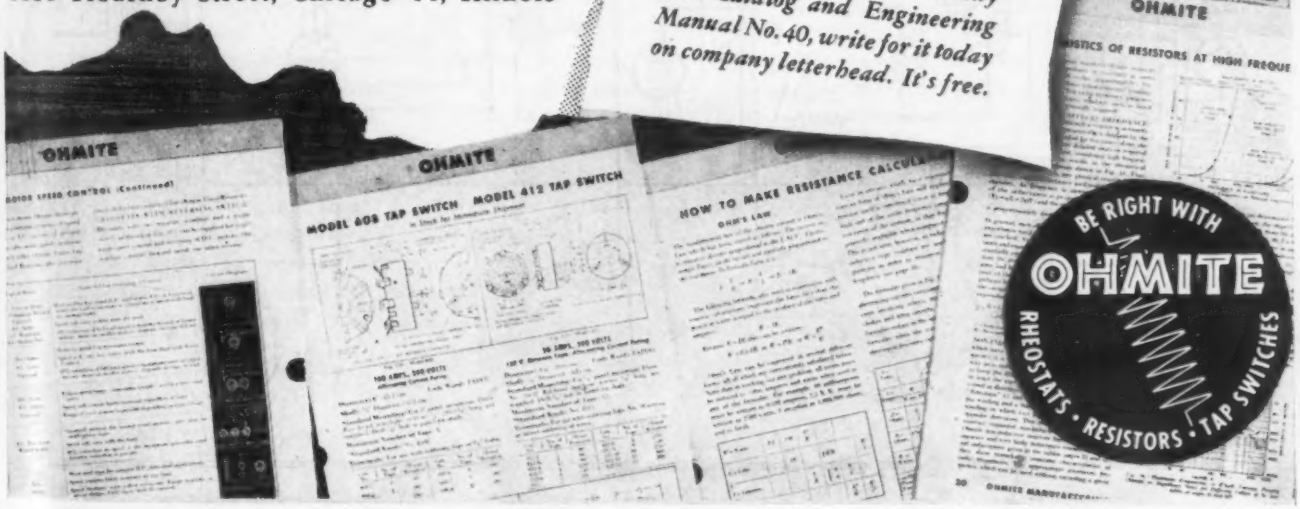


thinner mica windows may be used.

To seal the mica in place the metal flange is heated with a Bunsen burner and a thin coating of De Khotinsky cement spread over it. The mica is pressed down on the melted cement, care being taken to maintain even contact while the cement cools and sets. The glass bell is placed over the other end and the tungsten wires adjusted so that the glass bead at the tip is 1 to 2 mm above the mica. They are then sealed in place with De Khotinsky cement.

After cooling, the tube is evacuated and filled with a mixture of 10-percent ethanol and 90-percent argon, to a pressure of 10 cm of mercury. The tube is set in a fiber ring and mounted in a lead shield. The central wire is attached to the high positive potential, the metal cylinder to the negative lead of a Geiger-Mueller counter circuit, and the tube is then ready for use.

Samples to be measured may be mounted in ¼-oz metal ointment capsules which are placed directly under the mica window. In the case of Fe^{55}, the metal is plated directly onto the bottom of the capsule. Small Coors ashing capsules are also used.

REFERENCE

(1) W. F. Libby, *Phys. Rev.* **46**, 196, 1934; W. F. Libby and D. D. Lee, *Phys. Rev.* **55**, 245, 1939.

Elongation Recorder for Single Textile Fibers

PHOTOELECTRIC APPARATUS FOR making a continuous load-elongation record of single fibers of textiles at a constant rate of elongation, as well as a point-by-point record at a constant rate of loading, is described by A. M. Sookne and H. A. Rutherford in research paper RP1546, part of the *Journal of Research* of the National Bureau of Standards for July 1943. The apparatus combines the principles of a hand-operated machine formerly used at the Bureau and an automatic electronic balance developed by Muller and Garman[1]. Phototubes provide sensitive automatic operation and a kymograph makes possible autographic recording of the results of tests in rectangular coordinates.

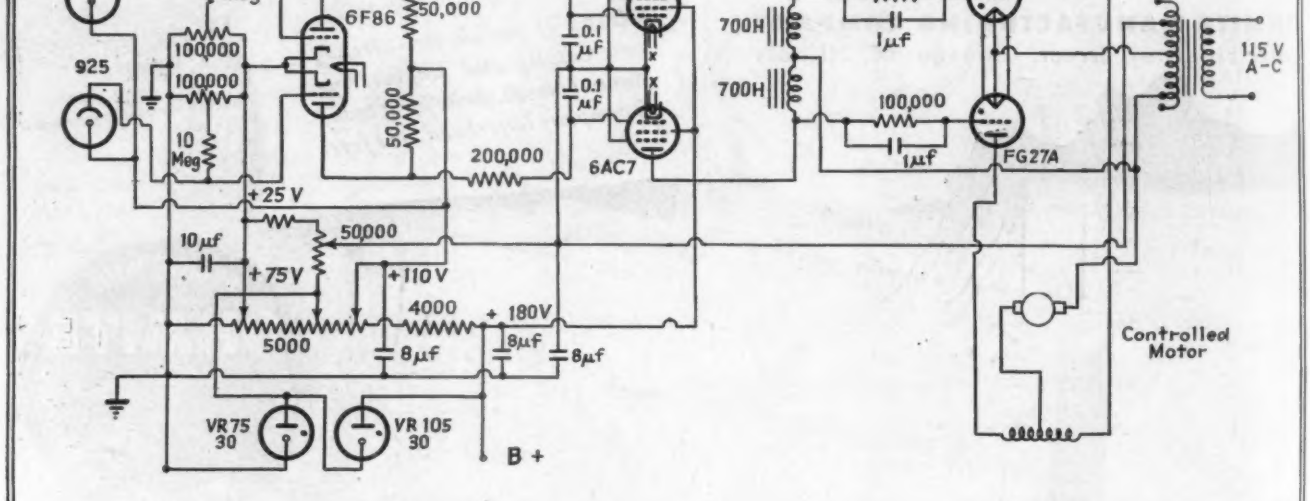
For testing single fibers of textile materials a modified chemical balance has been used to obtain load elongation curves[2]. The fiber was attached between one beam of the balance and a platform that could be raised or lowered by manual operation of a rack and pinion. Increments of load were then added to the other balance pan and the platform adjusted to return the balance pointer to zero. The degree of elongation was determined by measuring the displacement of the platform. Besides being tedious and slow the operation did not allow continuous stretching of the fiber.

The basis of the present apparatus consists of a magnetically damped analytical balance equipped with a Chainomatic column by which a chain is lowered to one side of the balance at a constant rate to provide a constant rate of loading. Elongation at a constant rate is obtained by lowering the platform to which the fiber is attached.

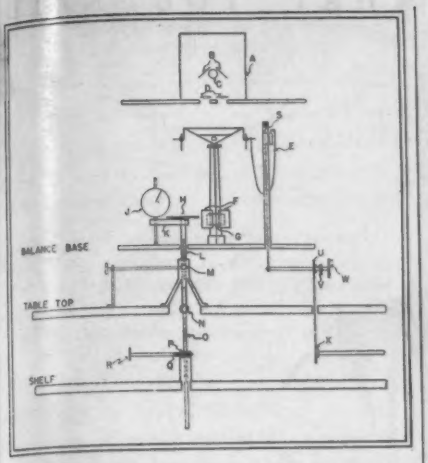
Construction of Instrument

The arrangement of the mechanical and optical components for the phototube control that maintains zero balance is shown in the cross-section diagram. One end of the fiber is attached to platform *H*, which moves dial gage *J* through arm *K* to indicate the amount of elongation, and the other end of the fiber is attached to the left arm of the balance. The platform can be moved manually by means of rack *L* and pinion *M*, or automatically by a constant-speed motor connected to sprocket *R* that drives worm *P* and tapped worm gear *Q* to raise or lower threaded shaft *O*.

Another sprocket drive assembly permits power to be applied to sprockets *X* and *U* to actuate the Chainomatic column *S* and control the amount of chain *E* that is applied to one arm of the balance. A clutch at *V* permits manual control of the



Phototube control circuit employed in autographic load-elongation apparatus for testing textile fibers



A single textile fiber is connected from one side of the balance arm to the platform *H* for tests of elongation. Motors, controlled by phototubes, lower the platform to stretch the fiber and simultaneously increase the load on the opposite end of the balance arm to maintain the pointer at zero

chain by wheel *W* if desired.

The arrangement of the light source that supplies the phototubes is also shown in the same illustration. A 21-cp lamp, *C*, is housed in box *A* so that two beams are reflected downward by two metal mirrors, *B*, through the condensing lenses *D*. Additional mirrors at *F* are placed symmetrically in front of the target *G* to send the beams past the target to the phototubes. Automatic control over the position of the balance pointer is obtained with the help of the target, which, when the system is in balance, interrupts approximately half of each light beam.

Phototube Circuit

The phototube control circuit is essentially that given by Muller and Garman[1] with the addition of several modifications suggested by Garman. The modified arrangement is shown in the circuit diagram. It consists of a conventional direct-coupled electronic amplifier circuit, and contains two thyratron tubes for control of the motor used to maintain continuous balance. Use of two phototubes makes the circuit independent of fluctuations of the light source. To protect the thyratron tubes from possible damage a time delay circuit is included (not shown in the diagram).

Motors for Mechanism

The controlled motor, used to restore balance, is a series-wound universal type and contains split field

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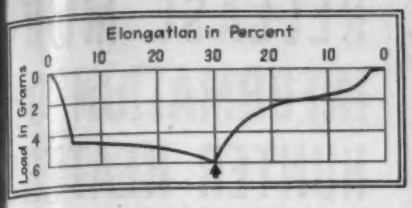
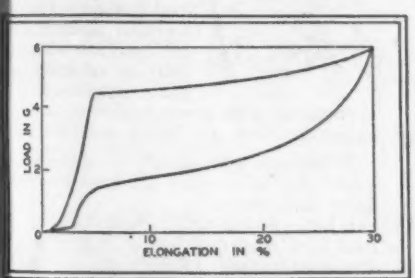


Loading and recovery cycle for a single wool fiber, stretched 30 percent in water. The arrow indicates the point of reversal of the platform motor. Folding the record sheet at the arrow produces a hysteresis loop

windings to allow reversing action. Stopping of the motor is provided by limit switches mounted at both ends of the Chainomatic column and at the lower limit of travel of the platform to prevent damage to the instrument. An additional reversible induction type motor is used to lower the platform and elongate the fiber under test. It provides a constant rate of elongation and also simplifies the problem of automatic recording of results.

A kymograph is mounted on a shelf below the table top for recording of load elongation curves. A constant-speed synchronous motor drives the mechanism and, since both the kymograph and the platform are driven by constant-speed motors, the abscissas of the record are directly proportional to the elongation. A swivel-mounted pen is attached to the Chainomatic column to record the load at any elongation.



Hysteresis loop of wool fiber, obtained by folding the record sheet at the arrow and tracing the curve

The authors state that successful operation of the machine depends upon the proper adjustment of the speed of the platform, the motion of the chain, the size of the chain used, and the sensitivity of the controls. The chain must be capable of moving rapidly enough to take care of the most rapid changes of load (usually in the Hooke's law portion of the curve) and should be light enough so that the scale of the ordi-

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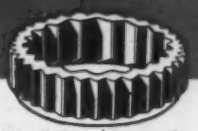

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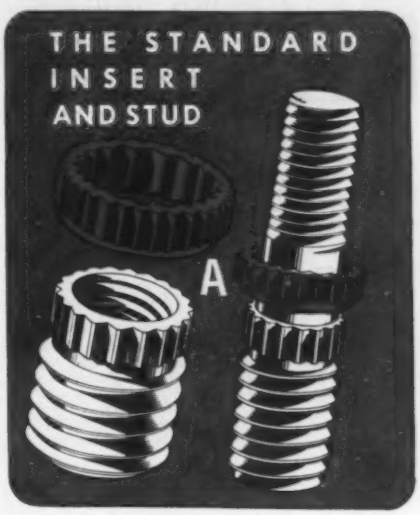

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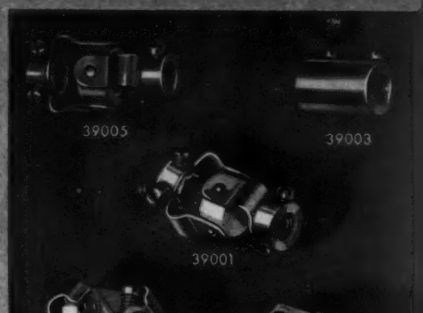

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nates is not unduly compressed. The scale of the abscissas may be easily adjusted by changing the speed of the kymograph drum.

A load elongation curve is shown for a wool fiber stretched at a constant rate in water. The fiber was elongated to 30 percent and then returned to zero elongation. The arrow indicates the point of reversal of the motor driving the platform. The conventional type of hysteresis loop, with load plotted against elongation, can be obtained from the curve by folding the record paper vertically through the arrow and then inverting the paper. A tracing made in this manner from the elongation curve of wool fiber is also shown.

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(1) R. H. Miller, and R. L. Garman, *Ind. Eng. Chem., Anal. Ed.*, **10**, 436, 1938.
(2) A. M. Soukne and M. Harris, *Bureau of Standards Jrl. of Research*, **19**, 535, 1937. RP1043; *Am. Dyestuff Reptr.*, **26**, 659, 1937.

• • •

New Signal Converter Tube For Television Circuits

A NEW TUBE that can convert a complete television signal into line and frame sweep voltages suitable for direct application to the deflecting plates of the cathode-ray tube in a television receiver is announced in a 27-page article by P. Nagy and M. J. Goddard of International Television Corp. in the June 1943 issue of *Wireless Engineer*, a British publication.

The new tube, called a signal converter by the authors, is slightly longer than an ordinary receiving tube but employs constructional principles similar to those of the electron gun in a cathode-ray tube. It is capable of delivering substantially linear deflection potentials of the order of 1000 volts when fed with input potentials of only a few volts. The complete television signal can be fed to its control electrode, without customary separation of line synchronizing signals from frame synchronizing signals. In one form, the tube will generate both line and frame sweep voltages, making it possible to replace all the synchronizing circuit tubes in a television receiver with just one signal converter tube.

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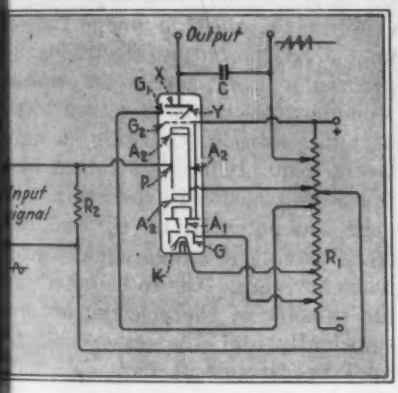
nchronization occurs at the beginning rather than at the end of each ne and frame. This feature is most pparent in connection with synhronization of multiple-interlaced ictures.

In the paper, basic principles of onventional time-base circuits are iscussed and compared with those f the signal converter. The various lectronic solutions to the problem of onverting a signal into its own time ase are discussed, and the reasons or adopting the electron optical deign of the Nagard signal converter s the best apparent solution to the roblem are presented in detail. Deign and construction data for the ube are given, uses in cathode ray scillography and in television are aken up in extreme detail, frequency nd output voltage limitations are nalyzed, a 19-item bibliography is ncluded, and Laplace's equations for he power of the cylindrical electron ns in the tube are developed in the ppendix.

Electronic Principles of Tube

The signal converter and its cirit are shown in schematic form in ig. 1. The tube symbol closely approximates the actual construction. stead of rotational symmetry, hower, the electrodes have rectangular rtures which set up an electron ns corresponding to a cylindrical ns in optics.



g. 1—Basic circuit of a signal converter tube

The cylindrical optical system, fosing the electrons to a line instead a point, was adopted to increase e total beam current to any reired value while retaining sharp cusing in the one required direcon. Electrons emitted from indictly heated cathode *K* are drawn the first anode A_1 through nega-

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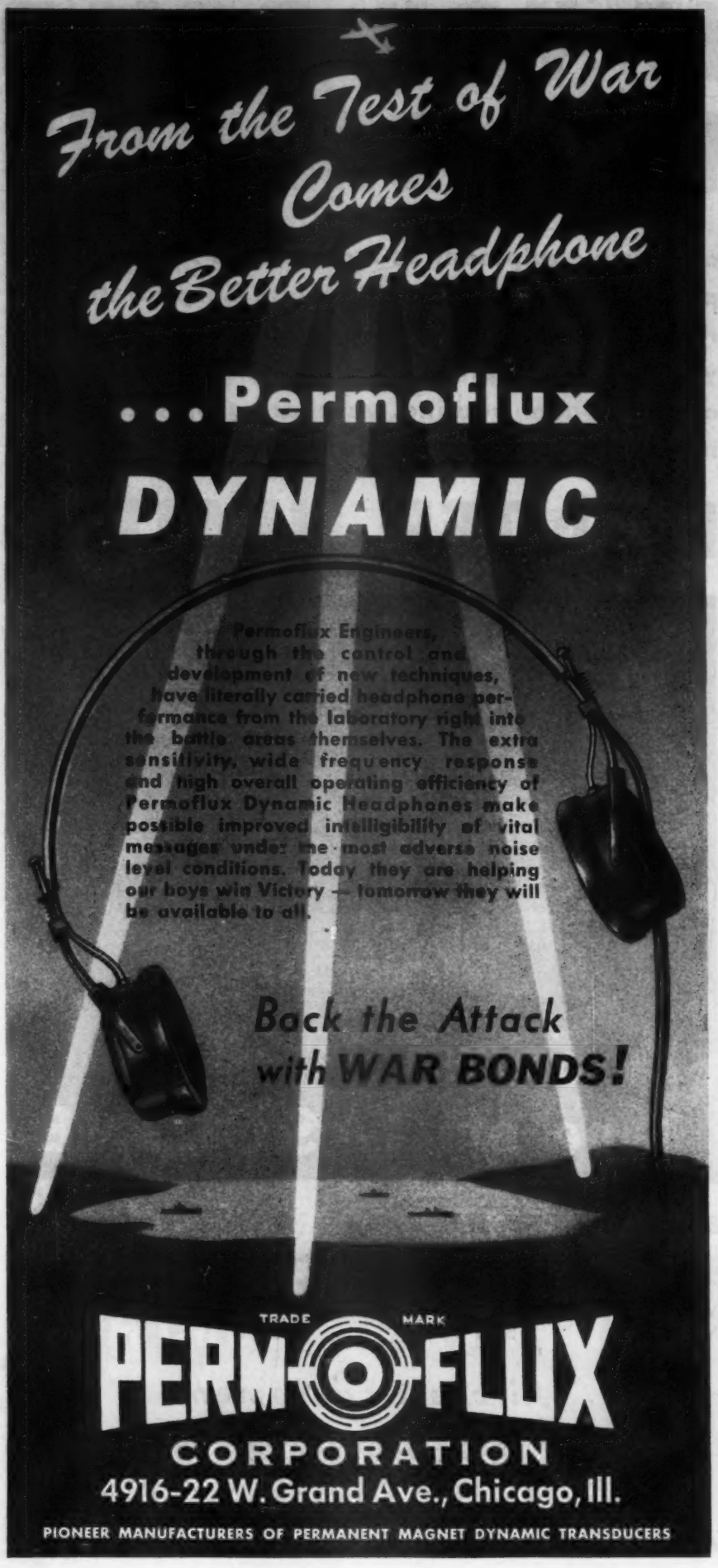
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tive grid G and are concentrated int a cross-over line near this grid. Th resulting narrow divergent beam then focused into a sharp line imag at the tip of member Y by the elec tron lens formed by anodes A_1 and A

Input signals are applied acros resistor R_2 and act on deflecting pla P, causing the electron image to b deflected across output electrode X This electrode has two parts, bot coated with substances having hig secondary electron emission (greate than unity, so that more electron are emitted than are arriving at th surface).

When the electron image falls o part Y of the output electrode, th electrode becomes positively charge because all its secondary electron are collected by screen grid G_2; wit more electrons leaving than arriving the output electrode loses electron at a steady rate and hence become increasingly more positive unt it reaches an equilibrium poten tial near the potential of G_2, which i at first anode potential.

The load of the signal converter i the pure capacity C connected be tween the output electrode and th voltage divider. The output voltag V across this capacitor is determine by the charging current i, the charg ing time t and the capacity valu C: $V = it/C$. This voltage is propor tional to charging time if the bea current and the secondary electro coefficient remain constant.

When the electron image falls o part X of the output electrode, sup pressor grid G_1 forces the emitte secondary electrons to return to th output electrode, charging it nega tively. Equilibrium is attained whe the output electrode reaches a valu near the potential of G_1, and elec trons leaving are then equal to elec trons arriving. It is to be noted tha the velocity of the electron beam i sufficiently high that essentially th total beam current passes throug G_1.

Wave Form of Output

When an alternating potential i applied to the deflection plate, th electron image is made to oscillat between the positive (X) and nega tive (Y) parts of the output elec trode, and a trapezoidal time-bas signal of the form shown in Fig. 2 i produced on the output electrode.

It is advantageous that the elec tron image should fall on the nega

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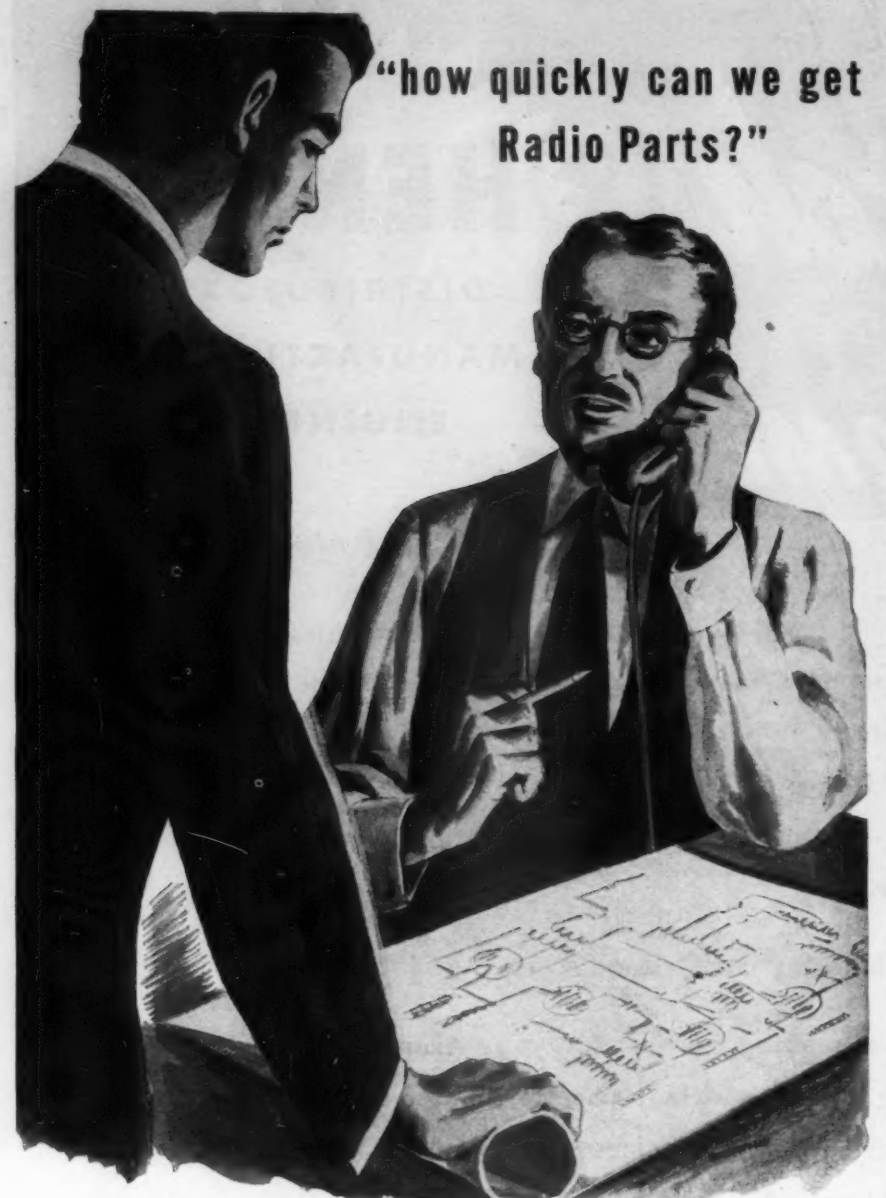

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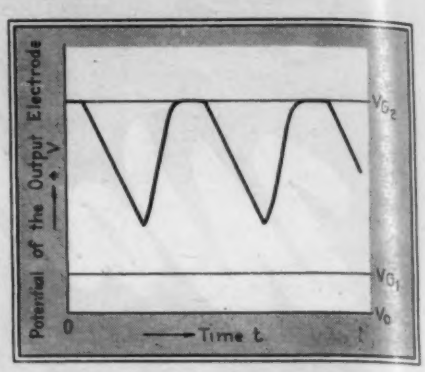

Fig. 2—One type of output wave form obtainable with a signal converter tube

tive part (*Y*) of the output electrode during the scan period, because here the change in output potential is a direct linear function of charging time (it is independent of secondary emission because all emitted electrons are forced back to the output electrode).

The width of the electron beam is made sufficiently small that the time during each oscillation when the image falls partly on each portion of the output electrode is negligible.

The smallest deflection necessary to produce an undistorted time-base output is theoretically equal to the beam width at the output electrode, but for safety it should be about three times that amount. If the beam width is 0.2 mm, the input voltage should produce a deflection of about 0.6 mm, obtainable with a minimum input amplitude of 0.12 volt. The input signal may increase as much as a hundred times during reception without affecting the constancy of the time-base output.

Television Applications

Advantages of the signal converter in television are greater simplification through elimination of the need for separating synchronizing signals from each other, practically negligible input power requirements of the converter tube itself, the possibility of combining the production of line and frame time bases in one converter tube, the possibility of simplifying the synchronizing signals themselves, the possibility of using multiple interlacing successfully, and the automatic and exact synchronization possible at the television receiver.

When the signal converter is employed, the scan of the time-base output automatically starts in synchronism with the *trailing edge* of

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Air-Wound coil construction—pioneered by B & W—holds many advantages:

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Air-Wound coils are ideal for plug-in services. They are not likely to be damaged if dropped—but, even if bent completely out of shape, can easily be repaired. For rough service, they can be further protected with "bumper" rings.

Air-Wound coils have low dielectric loss, can be wound to uniform pitch, offer greater design adaptability (note tapping indents in illustration) and lend themselves to mechanical and electrical revisions in the circuit.

Thus, while not a panacea for all coil problems, B & W Air Inductors spell greater efficiency for most of them. For other applications where form-wound units prove preferable, B & W offers a variety of types.

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There's nothing scientific about it, but when a B & W Inductor is dropped three stories (as illustrated) on to a cement sidewalk without being put out of commission, it at least proves the practical nature of Air-Wound construction. Actually, the only damage was a bent plug-in prong and a cracked ceramic support. The Coil was immediately "repaired" without tools of any kind, and operated perfectly!

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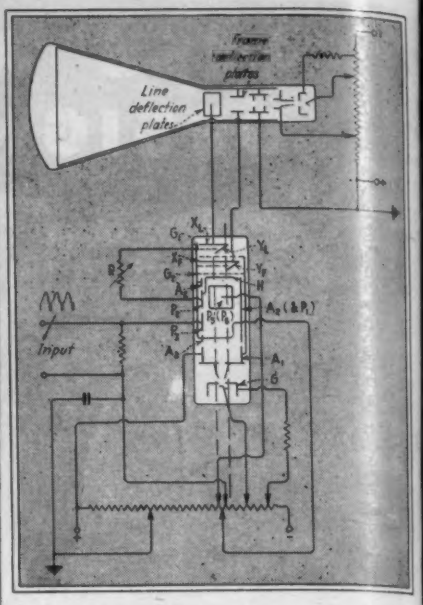


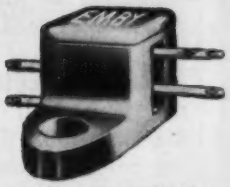
Fig. 3—Method of using a signal converter of the double output electrode type to generate both line and frame sweep voltages for a television receiver

the received synchronizing signal, and hence with the *start* of each line or frame.

In Fig. 3 is shown a circuit in which line and frame time bases for a television cathode-ray tube are produced in one signal converter tube. The line time base is produced on output electrode $X_L Y_L$, while the frame time base is produced on output electrode $X_F Y_F$. These two electrodes are actually side by side, so that a single electron image in the form of a long line falls on both electrodes. The operation of this circuit is fully explained by the authors in their paper.

Asymmetrical deflection, resulting in trapezoid distortion and defocusing of the reproduced picture, may be avoided by use of two conventional amplifiers which permit the use of all four deflecting plates in the picture tube, or by using two pairs of output electrodes in the converter tube, each pair connected to a separate pair of deflecting plates in the picture tube.

The signal converter thus offers excellent promise of simplifying the construction of television receivers while retaining the high quality of present receivers. The authors suggest a complete television receiver consisting only of two or three deflection-modulated cathode-ray tubes as amplifiers, one signal converter, two rectifiers for supply voltages and one cathode-ray picture tube.



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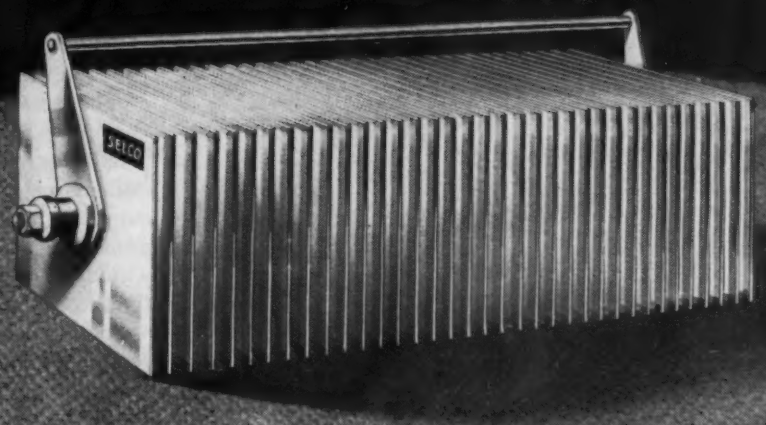

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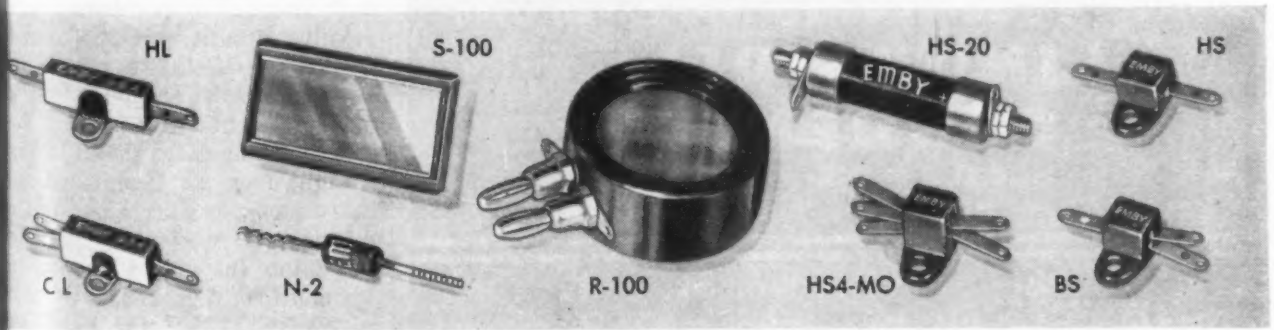

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Velocity of Radio Waves

A REVIEW OF VARIOUS METHODS t
have been employed for meas
ments of the speed of radio wave
contained in an address by R.
Smith-Rose, chairman of the W
less Section of the Institution
Electrical Engineers, published
the journal of the Institution
March, 1943. The paper exami
the present knowledge of the sp
of propagation of electric waves
all lengths from the visual to
radio-frequency spectrum.

In studying the existence and pr
erties of the ionosphere it is us
to measure the time interval betw
the emission of a group of waves
the receipt of the corresponding e
signal reflected from the ionosph
vertically above the observer. Fr
this interval the height of the
flecting region is deduced on the
sumption that, in the nonionized
gions of the atmosphere throu
which the waves travel, the speed
that appertaining to a vacuum.

Some methods of studying the
rection of arrival of radio waves
either the vertical or horizontal pl
are based upon the measurement
phase difference of the signal v
ages induced in two antenna syste
spaced a known distance apart. T
phase difference is dependent up
the ratio of this distance to the wa
length, and the latter quantity is
rectly dependent upon the speed
travel of the waves over the path
question. When this path is along
close to the ground it is important
know to what extent, if any, t
speed of propagation is affected
the electrical properties of t
ground.

Measurements of Velocity of Ligh

Various experimenters have sho
that the velocity of light in air is
the neighborhood of 3×10^{10} cm p
second and that the value is less
water than in air. The most rece
and accurate measurements of t
velocity of light were published in
paper by Michelson, Pease a
Pearson in 1935. They used an ev
uated steel tube a mile long and
mirror arrangement shown in Fig.

Light from an illuminated slit
is reflected from the upper half of
rotating mirror *D*, through a wi
dow *L* into the side of the steel tu
By multiple reflection between t
mirrors *G* and *H* the light wav

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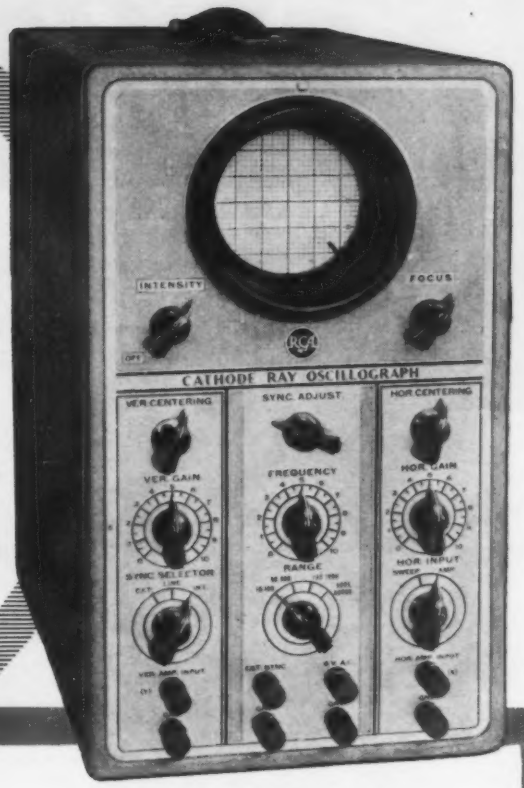

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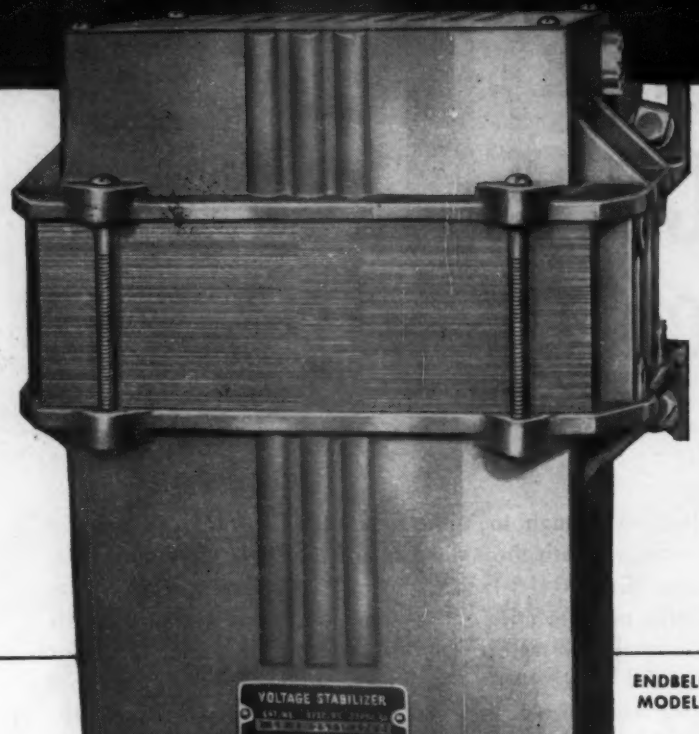

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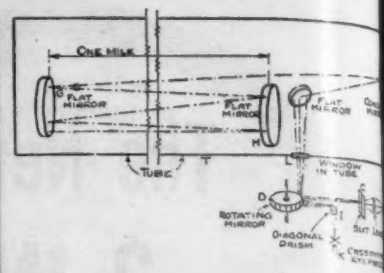

Fig. 1—Optical arrangement for determining velocity of light with a rotating mirror, as used by Michelson, Pease and Pearson. A light beam is passed back and forth in an evacuated steel tube a mile long, before being reflected to a rotating mirror. When the system is properly adjusted the time taken by the light beam to traverse its path is 1/32 of the mirror rotation speed

were caused to traverse a total path of about ten miles before being returned through the window L to the rotating mirror D. The returning beam of light was reflected from the lower half of the rotating mirror through the prism I to the observer's eyepiece K. If the speed is so adjusted that the image is in the center of the field of view, the time taken for the light to traverse its path of several miles is equal to ½ of the time of rotation of the mirror. Nearly 3,000 determinations of velocity were made over a period of years and the mean value was established as 299,774 km per second with an average deviation of 11 km per second.

Another method, employed by C. Anderson[8], utilizes the principle of modulating the light beam with radio-frequency energy by means of a Kerr cell and is shown in Fig. Anderson[8] later corrected for the group velocity delay caused by the lenses and mirrors and reported a mean value in vacuum of 299,776 km per second with a deviation of 14 km per second.

Effect of Air on Velocity

Since for radio purposes we are rarely concerned with wave transmission in a vacuum these values will need to be multiplied by $1/\sqrt{\chi}$, where χ is the dielectric constant of the medium in question. For air under normal atmospheric conditions at the earth's surface in this country (England), the value of χ is about 1.0 and the corresponding value of velocity will be reduced to 299,670 km per second.

For transmission of radio waves

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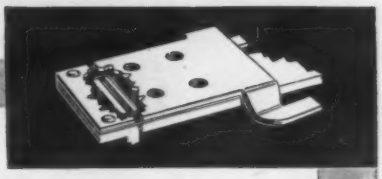
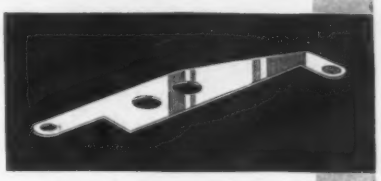


Hinge of "fatigueless" beryllium copper insures long life under vibration.



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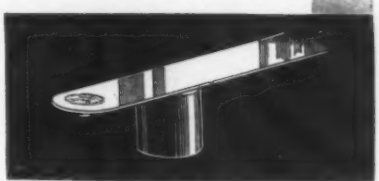

Strong, hard, long wearing Bakelite bushing insulators resist vibration and heavy contact pressures.

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Small and compact—measures only 1½" x 1¼" x 13/16"—the Type K, shown here, weighs but 1⅔ ounces. It is a definite contribution to design problems where weight and space are important factors.

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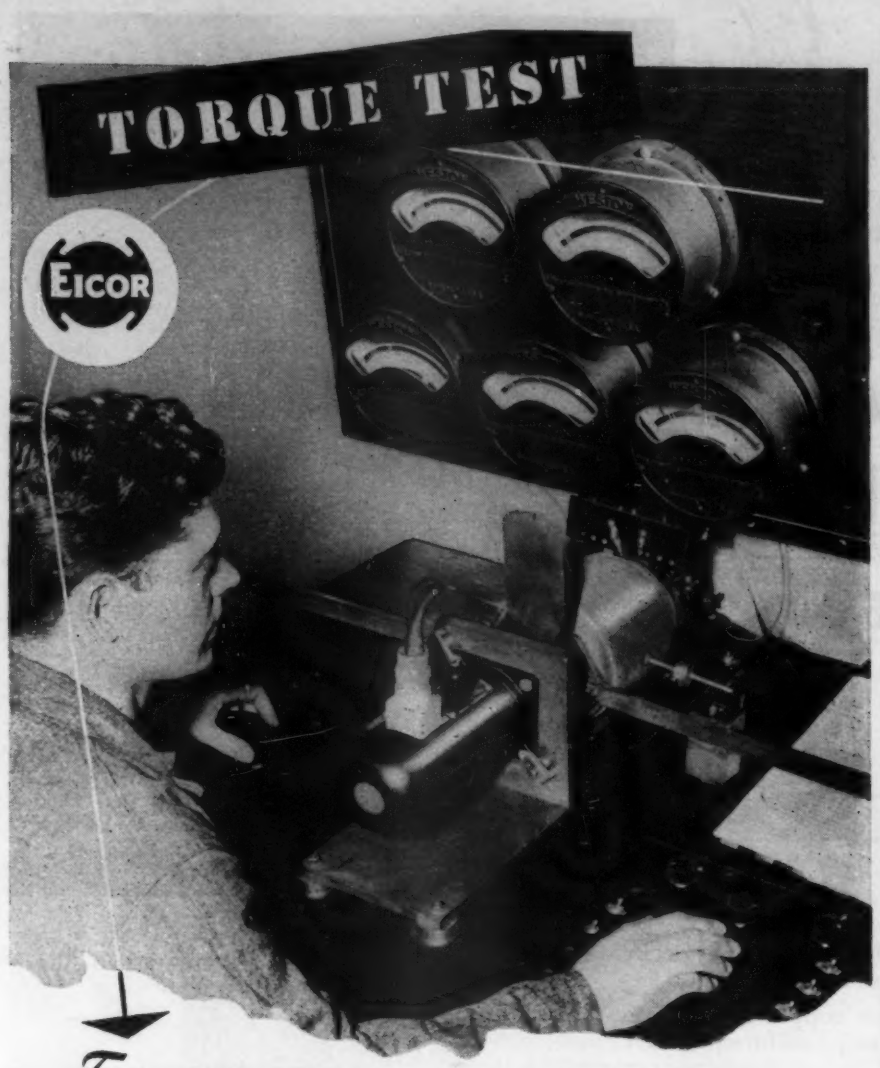

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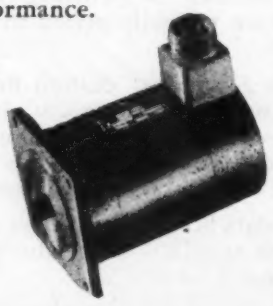

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over land F. T. Farmer and H. Mohanty[4] showed that the velocity of propagation for a wavelength of 166 meters (1.8 Mc) is within 6 or 7 percent of the velocity of light. These measurements were made with high frequency impulses and therefore refer to the group velocity of the waves; but their results are consistent with the phase velocity measurements of other workers.

Measurement of Phase Difference

A most comprehensive investigation of the velocity of medium radio waves was carried out during the years 1934–35 by a group of workers in the Laboratories of the U.S.S.R. under the direction of Profs. L. Mandelstam and N. Papalexi; the details and results of these investigations were published in a collection of papers in 1937.[5, 6, 7, 8] The method employed comprises a determination of the time of transit of waves between a sending and reflecting station by measuring the phase difference between the two sets of waves the ratio of whose frequencies is rational. The subsidiary investigations included the development of methods and instruments for measuring the phase difference between harmonic oscillations of different frequencies, and the study of the phase displacement introduced by high-frequency amplifiers.

A schematic arrangement of the method employed is shown in Fig. 2. The main station I radiates waves on a frequency f_1, a voltage corresponding to the outgoing frequency

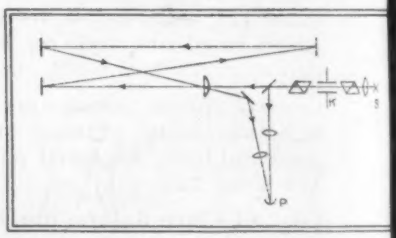

Fig. 2—Method of r-f modulation of light beam used by Anderson for measuring velocity. A light beam from source S passes through lenses and Nichol prisms and is modulated by Kerr cell K, that contains a liquid subjected to an alternating field of 14 to 56 Mc. The modulated beam is split into two parts by mirror M, one passing to phototube P, the other traversing a path of 10 to 20 meters between mirrors. Length of the path is adjusted for minimum output, indicating the beams arrive 180° out of phase. Difference of two paths corresponds to an odd multiple of half wavelengths at the modulation frequency

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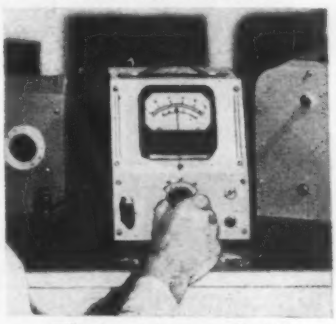

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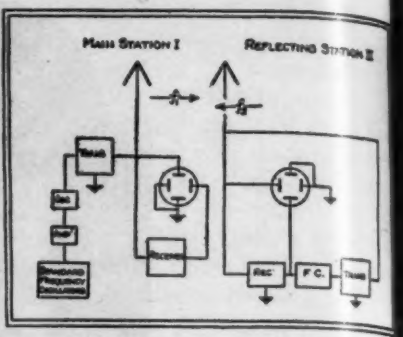

Fig. 3—Arrangement used by Mandelstam and Papalexi for measurements of group velocity of electromagnetic waves. Waves are sent from the main station to the receiving station, where they are changed in frequency and transmitted back to the main station and their phase compared to that of the original waves. The cathode-ray tube at the receiving station is used to maintain constant phase difference between incoming and outgoing waves

being applied to one pair of plates of a cathode-ray oscillograph. At the subsidiary or "reflecting" station II the incoming waves are received, then submitted to a frequency change in a simple but nonharmonic ratio (e.g. 3:2); then the oscillations of the new frequency f_2, after amplification, are transmitted from station II back to station I.

The cathode-ray oscillograph depicted at station II is used for the control of the phase difference between the incoming and outgoing waves, this phase difference being maintained constant during all experimental observations. The waves of frequency f_2 are received at station I and the resulting oscillations suitably amplified for application to the other pair of plates of the oscillograph at this station, so that the phase of the incoming waves may be compared with that of the waves originally emitted on a frequency f_1.

Under the conditions outlined, the trace on the screen of the oscillograph at I will be a Lissajous figure corresponding to the frequency ratio 3/2, its exact form depending upon the total phase difference of the outgoing and arriving waves. This phase difference may be expressed in the form

$$\phi_T = \phi_0 + \phi_1 + \phi_2 + \phi_3 \qquad (3)$$

where ϕ_0 = phase displacement suffered by the waves over the return path between stations I and II, ϕ_1 = phase difference introduced by the receiver at II, ϕ_2 = phase difference introduced by the transmitter at II

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and ϕ_s = phase difference introduced by the receiver at I.

If we can separate ϕ_s from the above measurements, we have

$$\phi_s = 4\pi fd/v \qquad (2)$$

where f is the frequency of the waves, d the distance between aerials I and II, and v the velocity of the waves over the path d.

The separation of ϕ_s was made by measuring the values of ϕ_1, ϕ_2 and ϕ_3 for the individual components of the apparatus in question, by using a phase-measuring technique which was developed to an advanced stage by E. Schegolev[7] and C. Viller,[8] two of the investigators associated with the group referred to above. An instrument termed a "phase deviometer" was constructed especially for use in the velocity determinations. This instrument includes simple scale arrangements for reading the phase indications directly off the Lissajous figures traced on the screen of the cathode-ray tube.

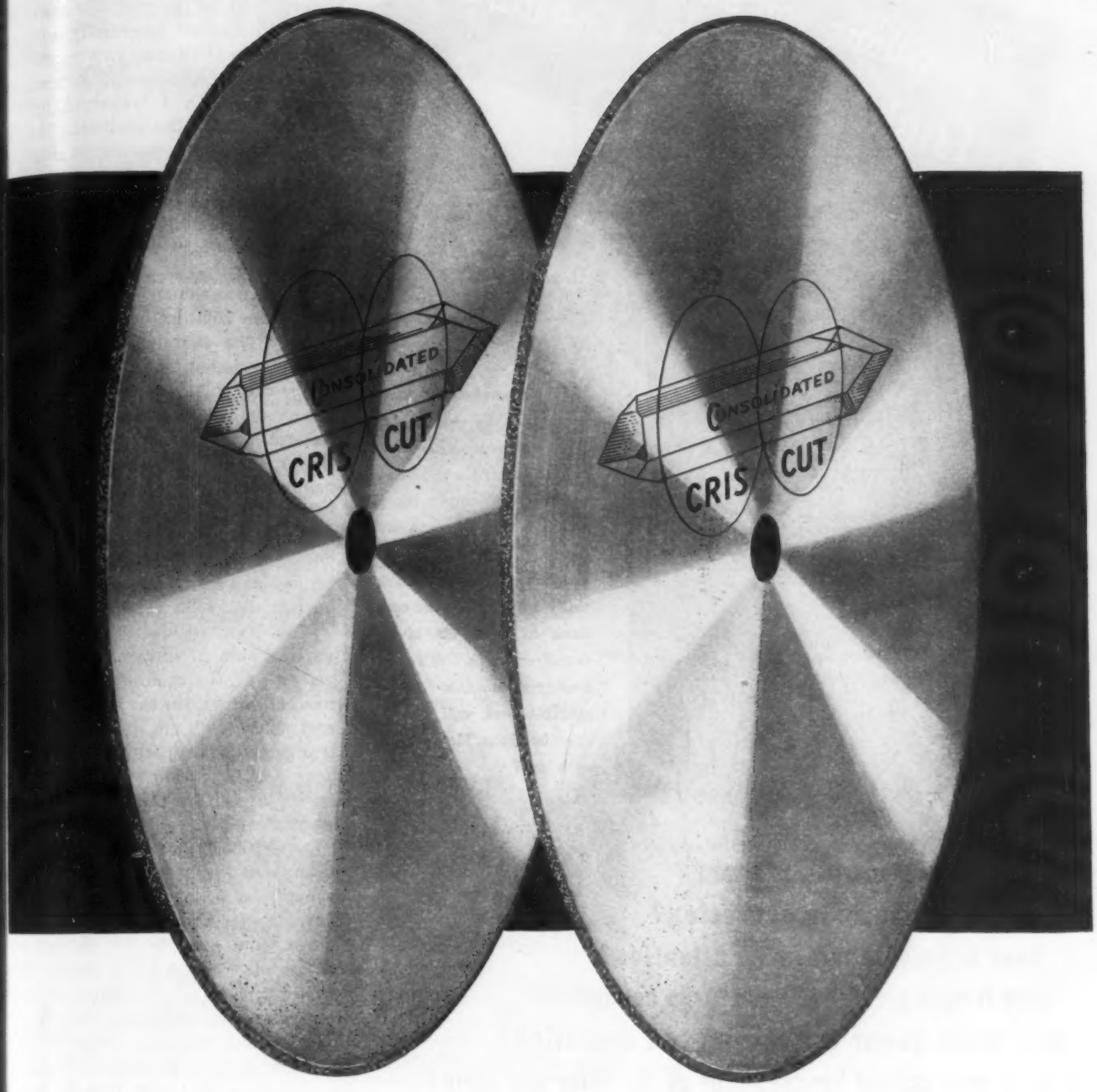
The phase displacement ϕ_s will in general comprise several complete cycles and may be expressed in the form

$$\phi_s = 2\pi(n+m) \qquad (3)$$

where n is an integer and m is a fraction.

In order to evaluate these two quantities, the frequency f_1 of the waves radiated from Station I is varied continuously over a small range, while the frequency of the synchronized waves from II is also changed so as to keep the frequency ratio constant, a matter that is easily checked by observation of the Lissajous figure on the screen at II. This frequency change is carried out between the limits accurately set by two quartz crystal standard frequency oscillators incorporated in the equipment at station I, so that the frequency range covered is known to a high order of accuracy. As the frequency of Station I is varied in this manner between the limits set by the standard-frequency oscillators, the number of complete cycles of phase-angle change is counted on the oscillograph at I, and the final fractional phase angle is also measured. In this way the total phase change ϕ_s is measured (Eq. 3), and the velocity of transmission of the waves is determined from Eq. 2. This technique is similar to that used in 1925 by E. V. Appleton and M. A. F. Barnett[9, 10] to measure the height of

CRIS CUT DIAMOND SAW BLADES



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the ionospheric regions, using a known value for the velocity of the waves.

Accuracy of Measurements

The accuracy of the measurements carried out by the methods described above depends essentially on the measurement of the two quantities, the phase displacement ϕ_0 and the length of path d traversed by the waves between the stations. The total phase displacements during the frequency-change process ranged from a few hundred to several thousand degrees, and the investigators were able to measure these to within 3 or 4 deg.; accuracy of phase measurement was thus of the order of 1 or 2 parts in 1000 in the most favorable cases. The distance measurements were carried out by standard geodetic survey methods, and appear in the most favorable cases to have been determined to an accuracy somewhat better than 1 part in 10^3 (0.1 percent). This implied that the centers of radiation of the antenna systems were known to a high order of accuracy, and to facilitate this the antennas at both stations were of the vertical-umbrella type.

The mean results obtained in the various sets of experiments for the velocity of the medium radio waves used all lie within the limits of 2.990 and 2.995×10^{10} cm per second for transmission over clear air path, or over sea or fresh water. As these limits are within the accuracy of the measurements, no definite conclusions can be drawn as to the effect of a salt or fresh water path on the velocity of propagation. In the case of transmission overland, a somewhat lower value of 2.950×10^{10} cm per second was obtained, although this would appear to be subject to some uncertainty in determining the true path of transmission, owing to various intervening obstacles.

Although the work just described has enabled a valuation for the wave velocity to be obtained, much of this and other investigation work has been directed by Mandelstam and Papalexi towards the development of what is termed an "interference range-finder." More recently than the work referred to above, some papers have been published by J. L. Alpert, W. W. Migulin and P. A. Riasin,[11, 12] in which the nature of the electromagnetic field near an antenna, and the effect of various con-

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ditions on the velocity of propagation to various distances, have received special attention. It appears that there is reason to suppose that the phase velocity of radio waves propagated over a flat and uniform surface is not constant, but may vary within a radius of three or four wavelengths from the source; this disturbance gradually disappears until, at a radius of some 50 wavelengths, the velocity is sensibly equal to its free space value.

Experiments have also been carried out to ascertain whether there is any dispersion in the transmission of waves over land and sea, in the range of wavelengths from 120 to 660 meters. The results of such experiments indicate that, for example, the velocity at wavelengths of 300 and 450 meters cannot differ by more than 0.07 percent for oversea transmission, whereas over dry land a difference of a few tenths of one percent is possible.

It is stated that balloon experiments have shown that the effect of the earth's surface on the field does not extend beyond a height of four or five wavelengths for the medium waves used. All this work would appear to be closely connected with Sommerfeld's classical investigations of the propagation of electromagnetic waves over the earth's surface, and to warrant considerable further study in connection with various radio problems and applications. It forms an interesting example of the manner in which fundamental investigations conducted from an apparently solely academic viewpoint may, in time, come to have important practical applications.

Conclusions

The velocity of light waves is known with considerable precision, and its value in vacuum may be taken as 2.99775×10^{10} cm per second. The modified value for light propagated through air under normal atmospheric conditions at sea level is 2.99670×10^{10} cm per second. The accuracy of measurement of these values is about 0.5 part in 10^4. It will be observed that the velocity value in air differs from the nominal figure of 3×10^{10} cm per second by about 0.1 percent. Modern radio-frequency technique has proved of considerable use in recent determinations of the velocity.

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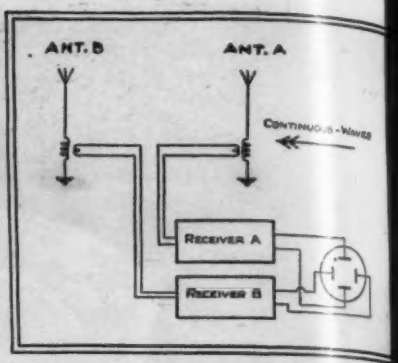

Apparatus used by Ross and Slow[13] for measurement of phase velocity of electromagnetic waves. Continuous waves were received from a source placed in line with the antennas and caused an elliptical trace on the cathode-ray tube. From this it was possible to determine the phase difference between currents in the antennas and the phase velocity of the waves between them

quency portion of the spectrum, the methods so far used for the determination of the velocity are much less accurate than this. It may be stated that within the limits of the experimental accuracy so far attained, which is not better than 0.1 percent, the velocity of propagation of medium radio waves is about 2.990×10^{10} cm per second. The experimental evidence so far available indicates that this value for the velocity is the same for all radio wavelengths within the accuracy specified above. There is some evidence that the phase velocity may be reduced below this value near the transmitting aerial, and it may also be modified when transmission takes place close to the surface of the earth; but it seems doubtful whether this variation from the free space value amounts to more than the experimental accuracy, except where obstacles such as trees and mountains intervene in the path of propagation. In this case it is not necessarily the velocity which has altered, but rather that the path traversed has been increased.

This discussion leaves the problem of the measurement or calculation of the actual time of transit of radio waves between sender and receiver still open to investigation. This type of information may be required for a number of purposes such as the use of time signals for the comparison of chronological standards and for the determination of differences of longitude. For the solution of this problem a knowledge of

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the free space speed is only one re
quirement; it still needs a preci
specification of the actual path, re
tilinear or otherwise, followed by th
waves, and of any modification to th
velocity value produced by atmo
pheric or ionospheric conditions.

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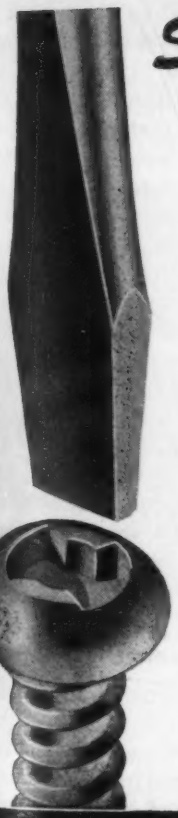
MINE DETECTOR DEMONSTRATION

Workers of a London factory making land mine detectors were able to see them in action in a demonstration in which real mines were used. Photograph shows the sapper in the foreground using the long handled detector to clear the way for a raiding party



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V-T Voltmeter

(*Continued from page* 104)

sible to limit the total current which can flow through the meter, even with a severe overload at the voltage input terminal.

In order to assure that the voltmeter produces an accurate indication at all times, a somewhat unusual method of checking the calibration has been applied. This method consists of using a Mallory grid-bias cell as a standard with which the a-c operated circuit can be calibrated. A bias cell is useful for this purpose because of its very small size and because it maintains a constant terminal voltage over long periods of time. If the cell has first been aged for about 1000 hours, and if no direct currents larger than 10^{-7} ampere flow in the cell circuit, the output voltage of a 1½ volt cell may be expected to be maintained under normal temperatures to within ± 2 percent of its original value for at least two years.

Two of the range switch positions are labelled "Cal. 1" and "Cal. 2". These are used for checking the calibration of the meter by the method outlined above. When the switch is at "Cal. 1" a known direct voltage from the bias cell is connected between ground and the bottom of the voltage dividing resistor. The adjustable resistor R_4 is varied until the meter deflects to a calibration point on the scale of the moving pointer meter. The range switch is then set to Cal. 2, and the resistor R_5 is adjusted to give a meter indication of zero. These two adjustments are repeated in succession until the meter indicates zero at Cal. 2 and up to the marked point at Cal. 1, at which time the instrument is correctly calibrated. Ordinarily this calibration operation should not have to be done oftener than once each week, even under conditions of heavy service of the meter.

Characteristics of the Vacuum-Tube Voltmeter

The voltmeter constructed on the basis of the circuit of Fig. 4 has been found in practice to be entirely satisfactory. Experimental checks show that changes of ± 10 percent in line voltage result in variations of less than ± 2 percent in the indication of the meter throughout all

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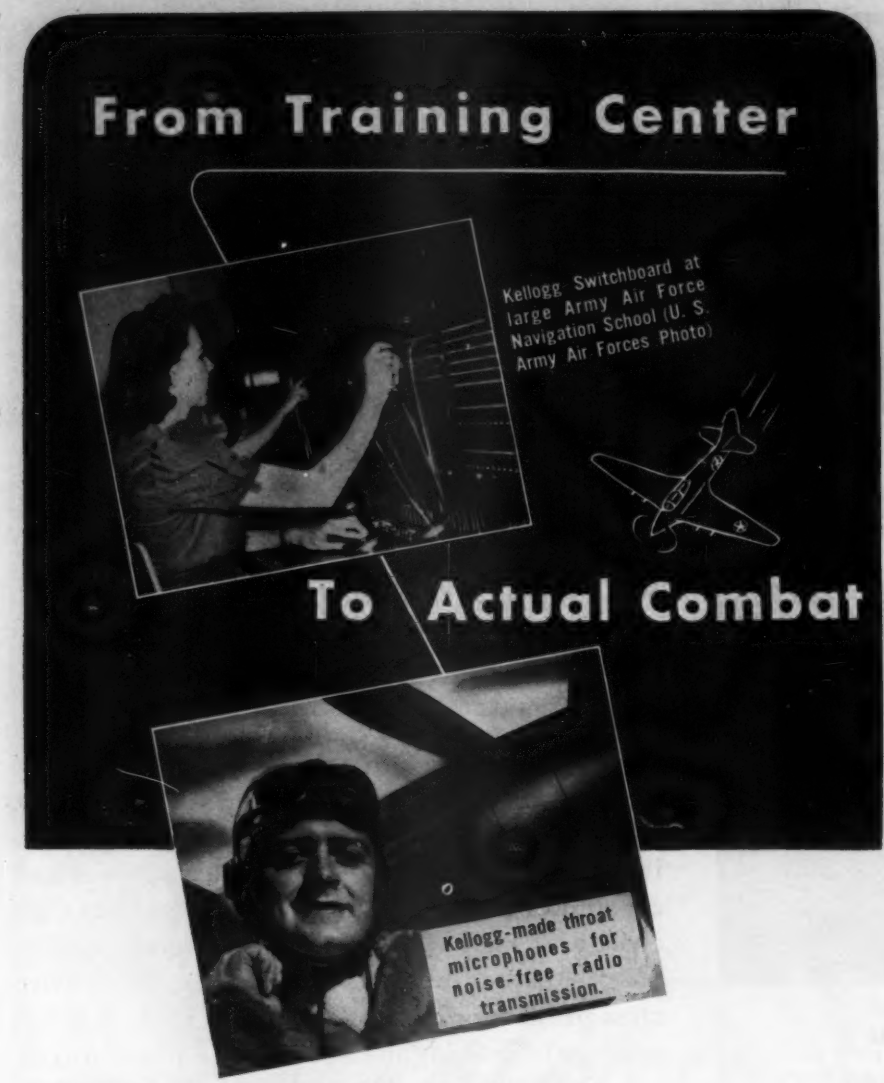
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position is a resistance of 10 m
ohms shunted by a capacitance of
micro-microfarads. With the swi
on the a-c position, the "impedan
is rather complicated because of
rectifier action of the diode, but
loading effect upon most circuits
countered in ordinary laborat
work has been found to be negligi
small.

With a General Radio model 72
vacuum tube voltmeter as a standa
the a-c operated voltmeter as here
described can be considered to
useful and reliable for frequenc
between 50 and 20x10⁶ cps. Over t
range, the a-c operated voltme
should be accurate to within 5 p
cent of full scale deflection.

Any vacuum-tube voltmeter of t
peak-reading type, of which the
strument under consideration is
example, is subject to serious erro
if a calibration based upon ro
mean-square sinusoidal voltage
used to measure voltages of no
sinusoidal wave form. A percenta
error, equal to the percentage
harmonic amplitude present in t
voltage being measure, is possib

The a-c operated vacuum-tube vo
meter as constructed measures 6
by 11 in. by 4 in., so that it is sm
enough to carry conveniently. Bas
upon prewar prices, the total value
the parts used in the voltmeter is l

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Type 5F
1⅜" x 1⅜" x 1⅝"
Weight: 3½ oz.

Won't Disturb the 0.0005 Watt Adjustment of SIGMA'S Series 5 Sensitive Relay*

With 0.005 Watt Adjustment, Will Operate...

—while subjected to simple harmonic vibration of 14 g's in any plane

—At Ambient Temperature: −60°C to +90°C with no change in performance.

...and meet all aircraft specifications

Interesting Facts

★ Contacts rated from 2-10 amps depending on requirements and conditions.

★ Extremely efficient 2-coil magnetic circuit.

★ Use of Hydrogen Annealed Nickel-Iron eliminates residual effects.

★ Conical pivots prevent armature play.

★ Duralumin I-Beam subframe construction for great mechanical strength.

*0.0005 Watt Adjustment Satisfactory for Light Duty Stationary Installations

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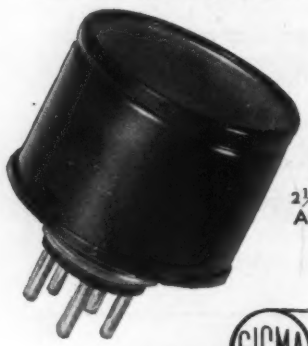

SIGMA
Type 5A
2⅛" Dia. x 1¾"
Above Socket

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1½" x 1½" x 2⅝"
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SIGMA
Sigma Instruments, INC.
Sensitive RELAYS
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than $25, a reasonable figure. Thus in both size and cost, the a-c operated instrument is satisfactory when compared with existing commercial vacuum-tube voltmeters, and its stability and accuracy have been found adequate for ordinary laboratory use.

The author wishes to acknowledge his indebtedness to Mr. G. T. Coate of M. I. T., who did some original work on a-c operated amplifiers and thereby stimulated this research, and to Professor T. S. Gray, of M. I. T., who offered many helpful suggestions during the experimental work.

Appendix

During the study of a-c operated vacuum-tube circuits, it became necessary to have some method for determining the operating conditions of the vacuum-tubes. There proved to be very little available literature on the subject,[a, b] so that it was necessary to develop some new graphical and analytical methods which would apply. Because of their simplicity, the fact that pentodes seemed to offer no particular advantages and because double triodes were available whereas no applicable double pentodes seem to be manufactured, triodes were used in the vacuum-tube voltmeter which was developed. For these reasons, the following analysis applies to triodes only.

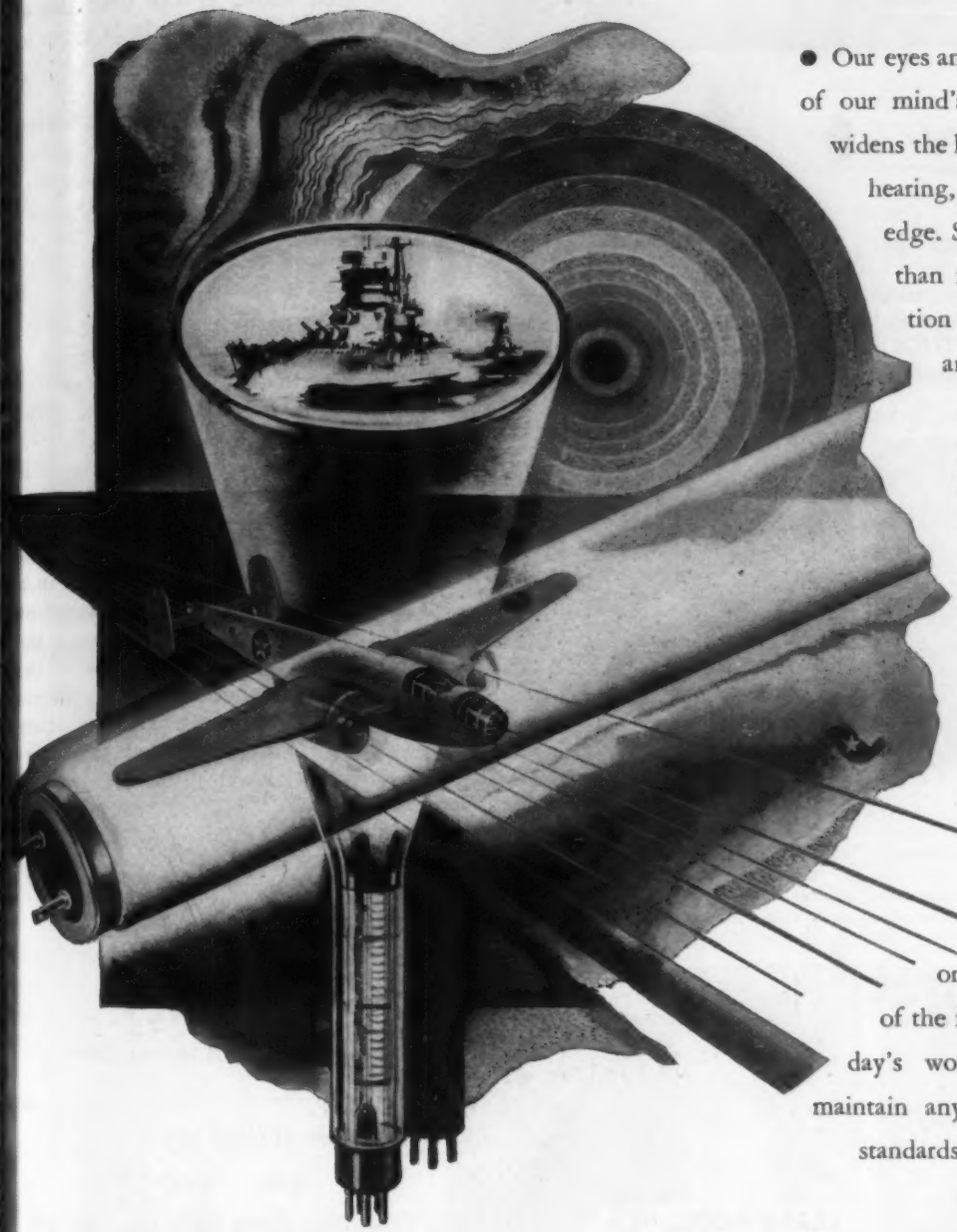
The list of symbols used in the analysis is given below so that the calculations and discussion may be followed more easily. Some of these symbols appear in Fig. 5.

E_c = Direct voltage rise from cathode to grid.
E_{bb} = Direct plate supply voltage.
E_b = Direct voltage rise from cathode to plate.
E_{bc} = "Cut-off" plate voltage for a given E_c, defined by $E_{bc} = \mu E_c$.
E'_{bb} = Peak value of alternating plate supply voltage rise from cathode.
I_b = Direct plate current.
i'_b = Peak value of plate current caused by the application of an alternating plate voltage of magnitude E'_{bb}.
α = The conduction angle, in radians, during which plate current flows when an alternating plate voltage is applied to the tube.
ω = Angular frequency of the applied plate voltage = $2\pi \times 60$ radians/sec in the experimental work.
μ, r_p, g_m = The usual dynamic tube characteristics.

Any other terms used are defined in the body of the analysis.

Tube characteristics of the type shown in Fig. 5 are assumed in this analysis. This is the standard assumption that the triode character-

To see and hear beyond the beyond

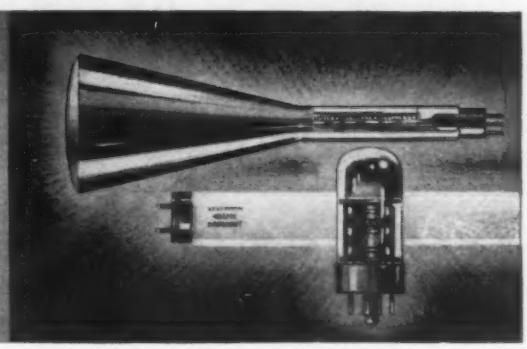


● Our eyes and ears are the advance guards of our mind's march forward. Whatever widens the horizons of human vision and hearing, reveals new vistas of knowledge. So our chosen work for more than forty years has been exploration of uncharted realms of sight and sound. Starting with the humble incandescent lamp, progressing to radio and electronic tubes, fluorescent lamps and equipment, we are today busy with ventures which are contributing vitally to the winning of the war. And important as these may be to Victory, their full flower will come as enduring boons to better living in the years beyond. How could anyone, glimpsing the rich promise of the future, be content to do each day's work with a firm resolve to maintain anything less than the highest standards known!

SYLVANIA ELECTRIC PRODUCTS INC., EMPORIUM, PA.

MAKERS OF INCANDESCENT LAMPS, FLUORESCENT LAMPS, FIXTURES AND ACCESSORIES, RADIO TUBES, CATHODE RAY TUBES AND ELECTRONIC DEVICES

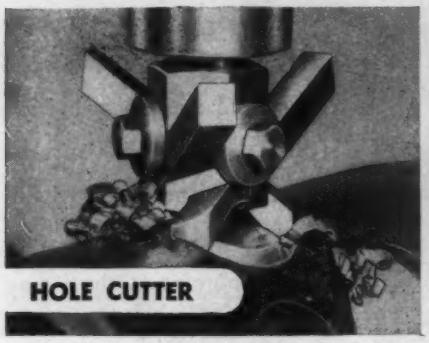
VITAL TO VICTORY is the ever-increasing number of electronic devices that miraculously bridge the gap between man and the machine tool in war industry. Electronic contributions to technology make inspection and processing more automatic and foolproof. From long experience, Sylvania has developed and applied electronic tubes to industrial as well as military uses.



HOW TO REPLACE CUTTING TOOLS
that can't be salvaged!

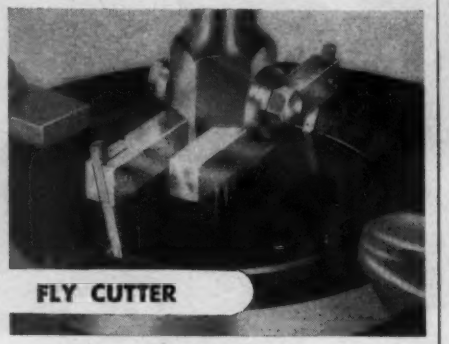
When worn or broken cutting tools can't be reclaimed for further service, replacement should be made with tools that conserve vital materials, time and labor. CLARK CUTTING TOOLS comply with these critical requirements, do better work quicker.

They use a minimum of tool steel, in cutting blades only; these can be resharpened repeatedly, replaced economically. Being adjustable, a few sizes do the work of many other tools, slash inventory. They make clean, *finished* cuts, reduce operations.



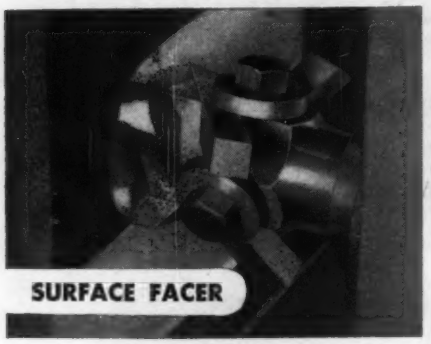
EXAMPLE NO. 1

Clark Adjustable 3-Blade Hole Cutters make accurate, smooth holes in flat or curved metal, plastics, wood, transite. 7 sizes cut ⅝" to 5", up to 1" thick. No reaming, deburring. Fewer operations are required.



EXAMPLE NO. 2

Clark Adjustable 2-Blade Fly Cutters. 2 sizes cut holes or discs 2½" to 10", up to 1" thick. Pitched blades cut true, relieve chatter. Other models cut gaskets, rings, discs from live rubber, problem materials.



EXAMPLE NO. 3

Clark Adjustable 3-Blade Facing Tools. 4 sizes cover all fractional diameters, 1¼" to 5", do the work of End, Shell and Slab Mills, Inserted Tooth Cutters. Fit all machines. Tools available with all types of blades, including carbide tips.

EXAMPLE NO. 4

A real tool bit conserver! Special Model C for accuracy, uniformity in grinding Clark Hole Cutter Blades. Also investigate Mechanic's MODEL A and Heavy Duty MODEL B for grinding *both* National 60° and Acme 29° tool bits—both models handle bits for use in Armstrong Tool Holders.

WRITE FOR BULLETIN NO. E-10

In Canada: DOMINION BEARINGS, LTD., TORONTO, MONTREAL, WINNIPEG
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Robert H. Clark Company

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istics are linear, parallel, and equidistant. A further assumption is made that the alternating plate voltage is sinusoidal. This was tacitly assumed above in the definition of ω. In Fig. 5, the angle is given by

$$\gamma = \sin^{-1}\frac{E_{bb}}{E'_{bb}} = \sin^{-1}\frac{\mu E_c}{E'_{bb}} \quad (1)$$

From the same figure, the conduction angle α is seen to be

$$\alpha = 2\left(\frac{\pi}{2} - \gamma\right) = \pi - 2\gamma \quad (2)$$

Thus

$$\gamma = \frac{\pi - \alpha}{2} \quad (3)$$

In Fig. 5 the plate voltage of the tube for the positive half-cycle is shown as the half sinusoid drawn below the tube characteristics. The amount of this voltage which is effective in causing plate current is determined by the grid voltage of the tube; in Fig. 5, the shaded area represents this effective voltage. The average plate current flowing in a tube operating under the conditions represented by Fig. 5 is simply the average of the plate voltage in the shaded area, divided by the plate resistance of the tube. Careful study of Fig. 5 will reveal that this average plate current is given by

$$I_b = \frac{1}{r_p}\cdot\frac{1}{2\pi}\left\{2\left[\int_{\gamma}^{\frac{\pi}{2}} E'_{bb}\sin\theta\, d\theta - E_{bb}\frac{\alpha}{2}\right]\right\}$$

$$= \frac{1}{\pi r_p}\left[\left(-E'_{bb}\cos\theta\right)\Big]_{\frac{\pi-\alpha}{2}}^{\frac{\pi}{2}} - \mu E_c\frac{\alpha}{2}\right]$$

$$= \frac{1}{r_p}\left[E'_{bb}\sin\frac{\alpha}{2} - \mu E_c\frac{\alpha}{2}\right] \quad (4)$$

Also from Fig. 5 it is seen that

$$r_p = \frac{E'_{bb} - \mu E_c}{i'_b} \quad (5)$$

Also from (1) and (2)

$$\alpha = \pi - 2\sin^{-1}\frac{\mu E_c}{E'_{bb}} \quad (6)$$

Therefore, from (4), (5), and (6),

$$I_b = \frac{i'_b}{\pi(E'_{bb} - \mu E_c)}\left[E'_{bb}\sin\frac{\alpha}{2} - \mu E_c\frac{\alpha}{2}\right] \quad (7)$$

But

$$E'_{bb}\sin\frac{\alpha}{2} = E'_{bb}\sin\left[\frac{\pi}{2} - \sin^{-1}\frac{\mu E_c}{E'_{bb}}\right]$$

$$= \sqrt{(E'_{bb})^2 - (\mu E_c)^2} \quad (8)$$

And

$$\frac{\alpha}{2} = \frac{\pi}{2} - \sin^{-1}\frac{\mu E_c}{E'_{bb}} = \cos^{-1}\frac{\mu E_c}{E'_{bb}} \quad (9)$$

Hence

$$\frac{I_b}{i'_b} = \frac{1}{\pi(E'_{bb} - \mu E_c)}$$

$$\left[\sqrt{(E'_{bb})^2 - (\mu E_c)^2} - \mu E_c\cos^{-1}\frac{\mu E_c}{E'_{bb}}\right] \quad (10)$$

This can be rewritten in a more useful form as given below:

Important Announcement to Users of Springs

In the interests of hundreds of engineers, designers, and production executives, to whom better coil and flat springs are of vital importance, Instrument Specialties Company is planning a comprehensive exhibit of "Micro-processed" beryllium copper springs and engineering data—to be shown at the National Metal Congress, Room 713, Palmer House, Chicago, from October 18th through the 22nd.

"Micro-processed" beryllium copper springs are setting new standards for spring design and performance. In the past nine months, Instrument Specialties has had innumerable requests for detailed information on the metallurgical, design, physical and electrical properties made possible by this process. Therefore, we are assembling under one roof in Chicago, the best informed members of our staff, who will be pleased to discuss with you any phase of Micro-processed springs and their most effective use.

The metallurgical director, chief design engineer, and others of the Instrument Specialties organization will be in attendance, backed up by technical information of real value to users of springs. This is our cordial invitation for you and your associates to make it a point to get at first hand the exceptional story of "Micro-processed" beryllium copper springs.

Room 713, Palmer House, Chicago,
October 18th to the 22nd.

INSTRUMENT SPECIALTIES CO., INC.

DEPT. D, LITTLE FALLS, NEW JERSEY

Sound your 'A'

We're going to "tune" a 400 cycle meter

Pitch pipes or ordinary tuning-forks are good enough for *musical* instruments where human error is expected —but not for *electrical* instruments. Tuning-fork electronic oscillators of our own design are used to calibrate J-B-T Vibrating Reed Frequency Meters because this is the most scientific, most accurate method we know of. Reeds are calibrated *twice*—once before assembly and later in the completed instrument. Before shipment each instrument is given a *final* check for accuracy of resonance.

Equally important to you is the J-B-T practice of "engineering" the *instrument* to fit the *job*. Take the new 400 cycle meter at the right. To obtain full reed amplitude *with* low power consumption at 400 cycles, special design and construction are required. For example, the reed mounts are considerably longer than in models for lower frequencies, and both driving coil and permanent magnets are mounted near the free ends of the reeds.

The new 400 cycle meter, like all other J-B-T Vibrating Reed Frequency Meters, requires no adjustment while in service, even under adverse vibration conditions. It is not affected by wave form, normal temperature changes or external magnetic fields. Simply READ the REED and that's your frequency.

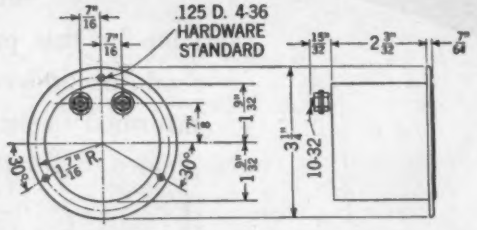
For full description of the complete line of J-B-T Vibrating Reed Frequency Meters, send for Bulletin VF-43.

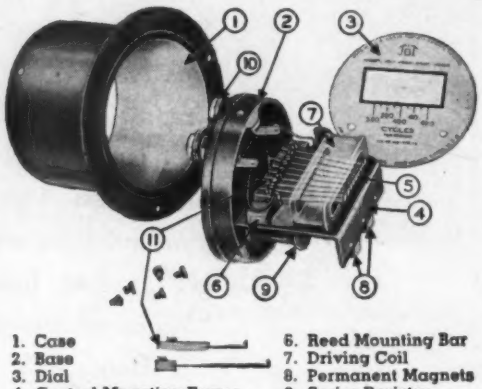
MODEL 33-F *for 400 Cycles*

Size . . . 3¼" flange diameter. Black metal* case for flush panel mounting. Single window type. 9 to 11 reeds.** Five or ten cycle increments. Accuracy . . . 0.3% under normal operating temperatures. Minimum voltage . . . 100. Power consumption . . . 1.75 watts. Ohms per volt . . .70.— at 400 cycles.

*Molded 3½" case to meet ASA specifications C39.2-1943 for mounting will be available shortly.

**9-reed instruments for 380-420 cycles in production; other ranges and reed groupings available on special order.





1. Case
2. Base
3. Dial
4. Central Mounting Frame
5. Spring Steel Reeds
6. Reed Mounting Bar
7. Driving Coil
8. Permanent Magnets
9. Series Resistor
10. Terminal Studs
11. Long Reed Mount

(Reed and reed mount from 60 cycle instrument—for comparison)

(Manufactured under Triplett Patents and/or Patents Pending)

10-JBT-3

J-B-T

J-B-T INSTRUMENTS, INC.

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$$\frac{I_b}{i'_b} = \frac{1}{\pi\left(1 - \frac{\mu E_c}{E'_{bb}}\right)}$$

$$\left[\sqrt{1 - \left(\frac{\mu E_c}{E'_{bb}}\right)^2} - \frac{\mu E_c}{E'_{bb}} \cos^{-1}\frac{(\mu E_c)}{E'_{bb}}\right]$$

The form of (11) makes it evide that the result is dependent on upon the ratio $\mu E_c/E'_{bb}$. Thus (1 is a universal equation that can used for any triode to which are a plicable the assumptions previous mentioned.

Since Eq. (11) is somewhat com plicated, the relationship betwe $\frac{I_b}{i'_b}$ and $-\frac{\mu E_c}{E'_{bb}}$ has been plotted in Fi 6. It will be noticed that this rel tionship, the solid line of Fig. 6, a proximates a straight line rath closely. The assumptions made in t preceding derivation are sometim rather far from the true state affairs, so that it seemed justifiab to approximate the calculated cur of Fig. 6 by the dotted straight lin This straight line has the equatio

$$\frac{I_b}{i'_b} = \frac{1}{\pi}\left(1 + 0.6\frac{\mu E_c}{E'_{bb}}\right) \quad (1$$

The form of (12) emphasizes t fact that the ratio of the direct pla current which flows in the tube the peak current is the average of half-wave rectified sinusoid dimi ished by a term which depends upo the magnitude of the grid bias. (No that E_c is negative for all the cas considered in this analysis.)

REFERENCES

(1) Coate, G. T., Unpublished notes, u in Course 6.201, M. I. T., Cambridge, Mas Summer 1942.

(2) Schwarzmann, W. A., Prediction of t Output of Alternating Current Operat Amplifiers, E. E. Dept., M. I. T., Bachel of Science Thesis, 1943. See also Pow Output of A-C Operated Amplifiers, by W. Schwarzmann, ELECTRONICS, August, 1943.

SILICON STEEL samples are in ductively heated to 2700 deg F wit 500-kc G-E induction heating equip ment to determine the carbon conten to an accuracy of 0.001 percent. Th lower the carbon content, the smalle is the core loss in transformers.

IMPLOSIONS of large cathode ra tubes invariably result in pulveri ing of the glass envelop, with start ling sound effects but no injury t those nearby and no large flying mis siles, according to "Diallist" writin in the British magazine *Wireles World.*

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Boosters
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The Solderless Terminal that
STAYS PUT
PERMITS uniform installation with unskilled labor. Provides a strong mechanical joint that withstands severe vibration.
Used by leading electrical contractors. Approved by prominent electrical engineers.
Cut down installation time and save valuable man-hours by using "Grip-it" Solderless Terminals.
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NEWS OF THE INDUSTRY

Machine gun sound effects; wire recorder for Army; science book for blind; spaghetti aligns filaments; free War courses; new calls for FM stations; standards for glass-bonded mica; wire sizes; I.R.E. Rochester Fall Meeting Program

Machine Gun Trainer with Sound Effects

A MACHINE GUN TRAINER that fires lead pellets instead of real bullets, and allows soldiers to hear sounds that simulate battle conditions, is being used by the Army and was shown to the public in the Army War show given by the Sixth Service Command on tour.

The gun is a mock-up of the regulation M-2 machine gun and contains an electro-hydraulic drive developed by G-E for firing 120 lead pellets per minute. The pellets are white and simulate tracer bullets that appear every five rounds in a standard machine gun. For use at night ultraviolet light and fluorescent bullets can be employed.

In training camps the gun is mounted so that model planes, suspended from wires, travel around and toward the gunner from all directions. The models are scaled and move at a speed to correspond to that of a real plane at 500-yard distance and can simulate plane speeds up to 500 miles an hour.

A phonograph record feeds into an amplifier to reproduce the sound of a standard 50-calibre machine gun amid typical battle noises. The amplifier system, developed by Operadio, supplies two large speakers mounted directly above the gunner's position. About 1,000 of the training guns are in use in army camps and it is estimated that they save a total of $10,800,000 every hour they are used for training.

Wire Recorders for Army

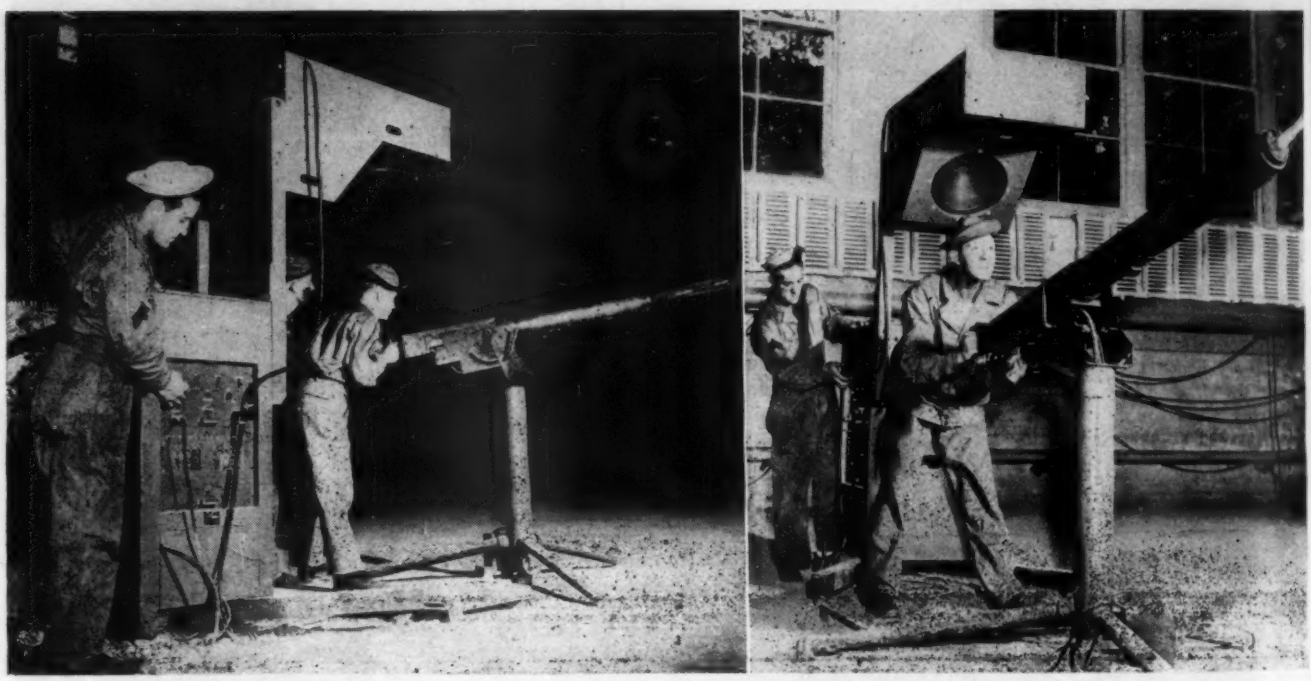
ARMY PERSONNEL in North Africa who cannot pick up U. S. radio programs directly are hearing the Army Hour broadcast and news programs from an electronic sound recorder and playback unit that uses wire instead of the conventional record.

Two news roundups and the Army Hour program broadcast are recorded on the wire each week by G-E engineers. Spools of the wire are then air-mailed to Washington, and from there are flown to Algiers by transport plane.

The photograph shows the combination recorder-playback unit in use. It records 66 minutes of continuous sound on 11,500 feet of thin steel wire that is rolled up on a small spool. The unit also permits erasing the recorded sounds from the wire so that it may be used over again.

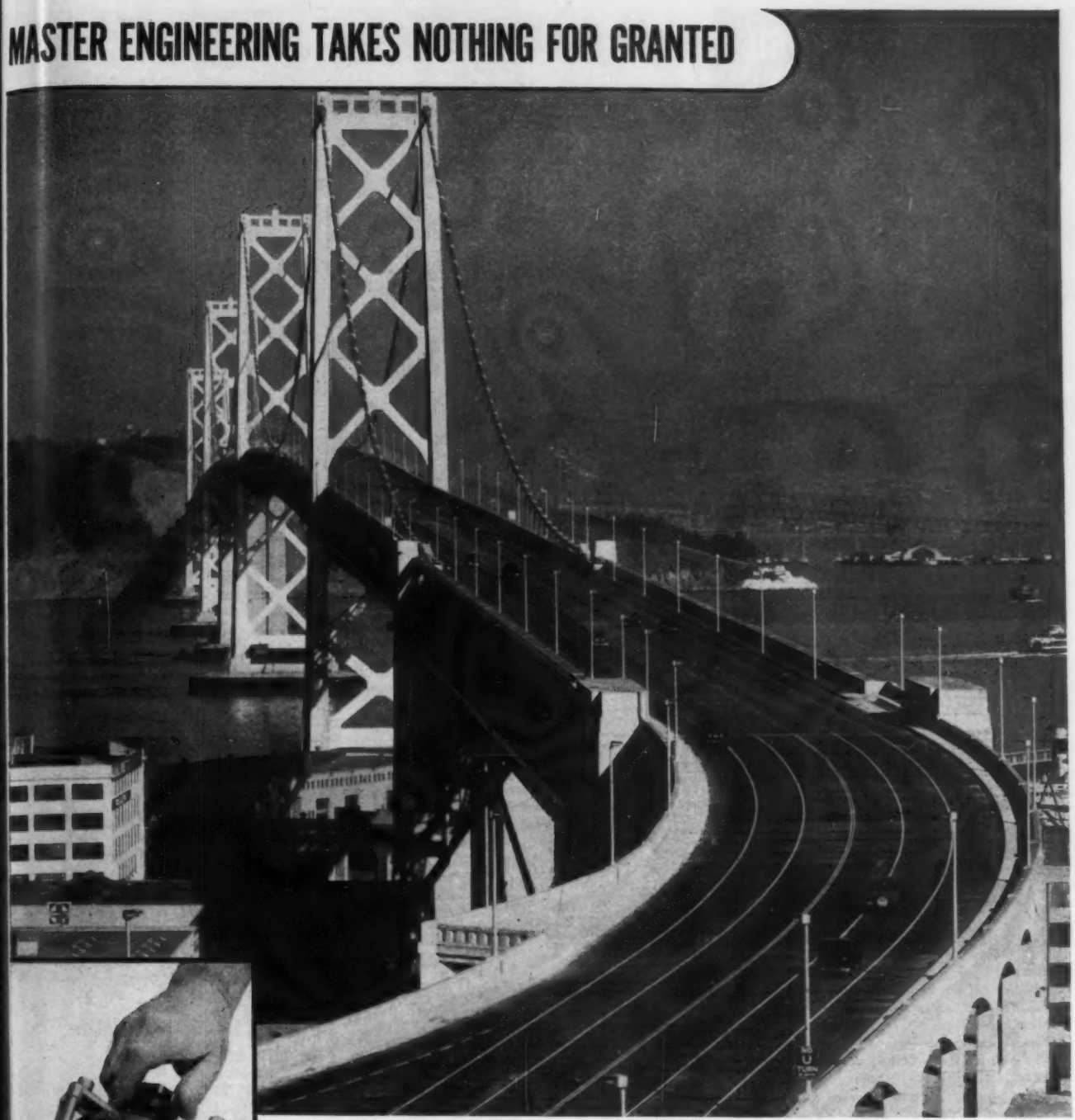
A portable wire recorder, also in production by General Electric, weighs about nine pounds and operates from batteries. This is designed for field service and has proven sucessful in experiments in jeeps and in planes 30,000 feet above the ground.

The army hopes that the portable recorder will bring a new dimension and flexibility to radio's coverage of



Machine gun trainer consisting of an electro-hydraulic machine gun and a sound amplifier that reproduces the sounds of a 50-calibre gun being fired against background noises of dive bombers, heavy guns and other battle sounds. Edison General Electric Co. engineers made the hydraulic gun, and Operadio Mfg. Co. developed the speaker and amplifier

MASTER ENGINEERING TAKES NOTHING FOR GRANTED



The size of the rivets . . . the gauge of cable wire were as carefully determined and important as the planning of the foundations for the great San Francisco - Oakland Bay bridge. Such master engineering serves to emphasize the fact that every tiny detail in an engineering project is of the utmost importance.

The products of Technical Radio Co., are not huge physically but they provide an example of what can result from the careful concentration upon every detail in engineering and fabrication. It is the job of Techrad engineers to produce radio parts and equipment and they've been doing it for over 10 years. Everything from a coil turret *(illustrated)* to the most complicated transmitter equipment. The dependability of the equipment, engineered and produced here, pays dividends in lives saved on the sea, in successes achieved on the battle fronts, and in the general improvement of radio communications.

Techrad engineers are firm believers in the principle that anything worth building at all is worth building well. For 10 years this basic idea has permeated the whole organization with the result that every Techrad product is backed by sound engineering.

TECHRAD PRODUCTS

708 TECHNICAL RADIO CO., 275 NINTH STREET, SAN FRANCISCO, CALIFORNIA

HEXACON ELECTRIC SOLDERING IRONS

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NEW! THE HEXACON HATCHET TYPE IRON

... perfect balance - less fatigue

Expressly designed for the multitude of complex and tedious soldering requirements, the HEXACON Hatchet Type soldering iron has found extensive use because of its extreme ease of manipulation.

Perfect balancing—permits long operation with minimum of fatigue. As with all HEXACON units, the Hatchet type is ruggedly constructed, and is tested for twice the intensity required by the Underwriters' Laboratories, assuring greater-than-average service life with economy and efficiency. Operates on AC or DC of any cycle, and is available in voltage ranges from 32 to 250 volts. Equipped with replaceable elements, and all other features of HEXACON Plug Tip Irons.

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Descriptive bulletins, describing the complete line of HEXACON electric soldering irons, will be sent on request.

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HEXACON

A wire recording of the Army Hour is taken off the air by A. W. Sear and E. A. Malling, G-E engineers. Wire spools, containing 65 minutes of the program, are flown to Algiers and played back to Army soldiers, officers, and war correspondents

the war, according to Colonel E. M. Kirby, Chief of the Radio Branch of the Army's Bureau of Public Relations.

"Radio reporters have been anchored to stationary radio transmitters in a war of movement," said Colonel Kirby. "If they go to the front they cannot broadcast until they return to the transmitters. In the southwest Pacific this means a distance of 1,500 miles both ways. In the Tunisian campaign, it meant several hundred miles, and for Sicily, another hour's plane ride. As a result radio has encountered, for the first time in its history, a limit of time and distance."

The army plans to loan the portable recorders to accredited network correspondents as soon as there are enough to insure even distribution among all the networks. On-the-scene reports from the war fronts can then be recorded for later broadcast to every American home.

Portable model of wire recorder, to be used by war reporters in the field, is examined by Colonel R. Ernest Dupuy, Chief of the News Division of the U. S. Army Bureau of Public Relations

Science Book in Braille for the Blind

STUDENTS IN SCHOOLS for the blind are eagerly reaching out for knowledge of science. In a recent class a demonstration of magnetism was prepared for the students. The teacher covered a horseshoe magnet with a sheet of paper and then sprinkled iron filings over the paper. With a gentle shake the filings arranged themselves into a pattern that reproduced the shape of the horseshoe magnet.

Next, each member of the class in turn placed his sensitive fingers on the paper and traced and retraced the path of the pattern formed by the filings, while the teacher explained the principles of magnetism. After he finished talking the room buzzed with questions and a lively

ROCKBESTOS "KNOW-HOW" BUILDS PERMANENTLY INSULATED WIRES For Electronic Applications

Actual size of No. 18 AWG 1000 volt Rockbestos Firewall Radio Hookup Wire

Construction Detail—Enlarged 4 Times

First, a color-coded braid of glass yarn (or cotton or rayon) lacquer-finished to a hard, smooth surface that never becomes gummy or tacky and is resistant to heat, cold, moisture, oil, grease, gasoline and cleaning fluids.

Next, a firewall of resilient felted asbestos, impregnated with heat, flame and moisture resisting compounds, that acts as a heat-barrier against high ambient temperatures and won't burn under copper-melting arcs.

Then a thin, tough, mechanically strong synthetic tape for uniform high dielectric strength and high moisture resistance.

And finally, a stranded tinned copper conductor perfectly and permanently centered in helically applied insulation that will not migrate or flow under heat.

SHIELDED ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

Made in the same construction as illustrated to the right, in single or multi-conductor, and covered with a tinned copper shielding braid. 1000 volt rating in sizes No. 18 to 4 AWG—3000 volt in sizes No. 12, 14 and 16 AWG.

ROCKBESTOS ASBESTOS INSULATED MAGNET WIRE

Designed for Class B windings, it is suitable for use as bus wire where high dielectric strength is not required. The insulation is non-checking and is unaffected by heat or aging.

ROCKBESTOS ALL-ASBESTOS LEAD WIRE

In sizes No. 20 to 8 AWG. Solid or stranded copper, monel or nickel conductors insulated with .031" or .040" of felted asbestos in black, white or colors. Won't dry out and crack under heat and vibration; rot, swell or flow under contact with oil or grease, and has ample moisture resistance for most applications.

ROCKBESTOS TYPE CA LEAD WIRE

In the same sizes and conductors as the All-Asbestos Lead Wire above and having the same characteristics, plus higher dielectric strength and moisture resistance provided by the synthetic tape beneath the felted asbestos. For applications in hot, humid locations.

A few of the 122 different wires, cables and cords developed by Rockbestos.

Here's a wire that gives you heat and flame resistant characteristics, in addition to unusually high dielectric strength—Rockbestos Firewall Radio Hookup Wire—designed in 1937 to satisfy the requirements of aircraft radio manufacturers for a small diameter, light weight, stable, flame and moisture-resistant construction, and used since in a wide variety of radio equipment and electronic apparatus.

It is resistant to heat, cold, flame, oil, grease, gasoline, moisture, alkalies and corrosive fumes.

It is made in two constructions—1000 volt rated, in sizes No. 22 to 4 AWG and 3000 volt in No. 12, 14 and 16 AWG.

It has a wide operating temperature range—won't dry out in insulation-baking heat up to 125° C., or become brittle in sub-zero cold as low as minus 50° C.

The 1000 volt wire has been subjected to life voltage tests at rated voltage and 125° C. rated temperature for 2500 hours without failure—and at rated voltage and room temperature for 8000 hours.

The 3000 volt wire has been subjected to test at 5000 volts and 125° C. for periods in excess of 700 hours without failure—and at the same voltage at room temperature for periods in excess of 1200 hours.

These are a few of the characteristics that have brought this type of wire into wide use in a variety of applications—characteristics that are basic in many constructions in the Rockbestos line of 122 permanently insulated wires, cables and cords. One of them may be what you are looking for, but if not, Rockbestos Research will do its best to develop a wire for you. Write or phone nearest branch or:

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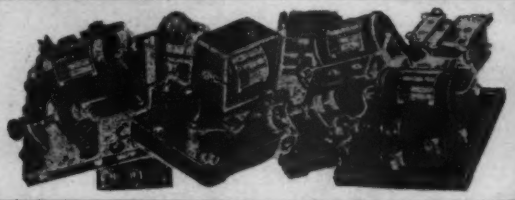

Kurman's Famous 23 Yr. Record Scores New High—99.00076% O.K.

Yes, maybe there are other relay manufacturers who could turn out a big order like this as swiftly as we did. But, only Kurman with its 23 years of experience, its unsurpassed facilities, its knowing what to do and how to do it could (we believe) do the job and have only 24 rejects. Here again is striking proof that confidence in Kurman when it comes to relays is valuable insurance when it comes to your product's performance. No matter how exacting your requirements may be for power and sensitivity, your best bet is "Consult Kurman."

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At the Western Pennsylvania School for the Blind, science teacher James Schroder guides the hand of Virginia Wolozyn while Robert Farrell waits his turn. Her fingers will trace the pattern formed by iron filings over a horseshoe magnet. A science textbook, printed in Braille by Westinghouse, is available for her use

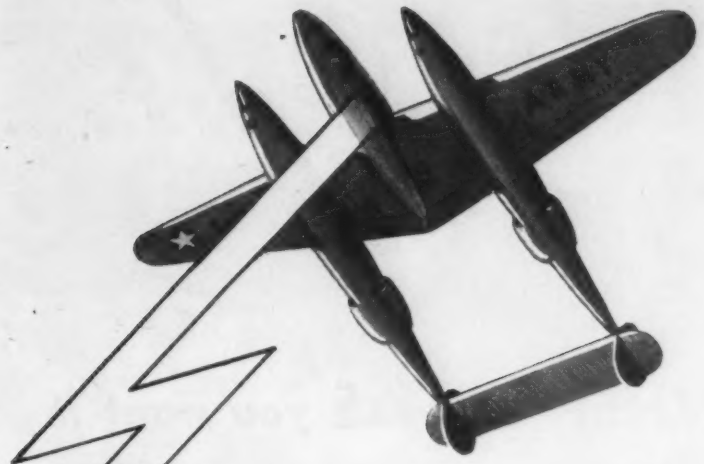
and lengthy quiz of the teacher ensued.

To help blind students explore the world of science a Braille edition of a booklet written by Westinghouse research experts is being distributed to schools for the blind by the School Service Department of the company. The booklet is one of the Little Science series, designed for students of high school age.

About 600,000 copies of the first four booklets have been printed in ink and supplied to schools throughout the nation. Charles MacLean, manager of the School Service, suggested making the series available in Braille to blind students, to further extend the scope of the series and render useful service. The project is still in the experimental stages, but as soon as the initial booklet has been given a thorough trial, consideration will be given to printing the remainder of the series in Braille.

Uncooked Spaghetti Helps Make Vacuum Tubes

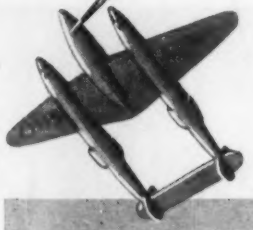
TUBE FILAMENTS are being aligned for welding by a piece of spaghetti (the edible kind), which is later burned off. The new technique, developed by William A. Hayes, electronics engineer in the Westinghouse Lamp Division, produces 50 percent more filaments than the old method and permits assembly workers to spend more time on other production jobs. A WPB Award of Individual

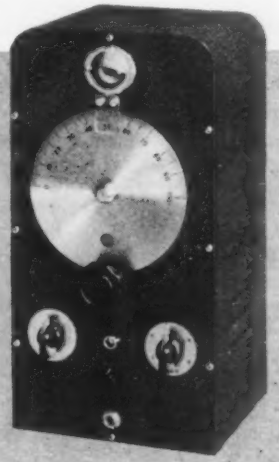


"ORANGE LEADER CALLING . . ." "ROGER!"

Pre-operational checking of transmitters helps make sure that messages will be received. Browning Frequency Meters (types S1 and S2) have for some years provided simple, comparatively inexpensive means for such checking. Type S2 is accurate to within .005%. They are easy to operate. They stand up under hard use. Full details are given in literature available upon request.

The balanced-capacitance Browning Signal System for plant protection without guard patrols is another product of Browning Laboratories research. A descriptive folder will be mailed when requested.





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Complete graduation of light—from bright thru intermediate glows to total dark within 90° rotation of the shutter is a feature of this Gothard Series 430 Shutter Type Pilot Light. Particularly applicable for aircraft, marine, signal and similar applications that require various intensities of light under constantly changing conditions. Sturdy construction—rigid non-short terminals—faceted or plain jewels. Also available with polarized lens. Colors: red, green, amber, blue or opal.

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HELICOPTERS—*the "flivver" planes of post-war tomorrow*—are just one of the many "miracles" becoming realities through industry's great war production drive.

For the greater our efforts to provide the boys on the fighting front with new and better *tools* of Victory—the more we uncover new techniques and skills, new materials, new products.

Through the mass production methods we are learning today, *precision* in these post-war products will be made economically available to everyone. And to manufacturers this will mean, better products, a better market, and better public goodwill.

(*Below*) Some of our precision-made parts that are helping bring Victory closer, and which will help mould our world of tomorrow.

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SCREW MACHINE PRODUCTS CO., INC.

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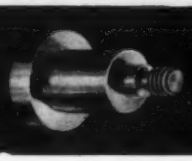
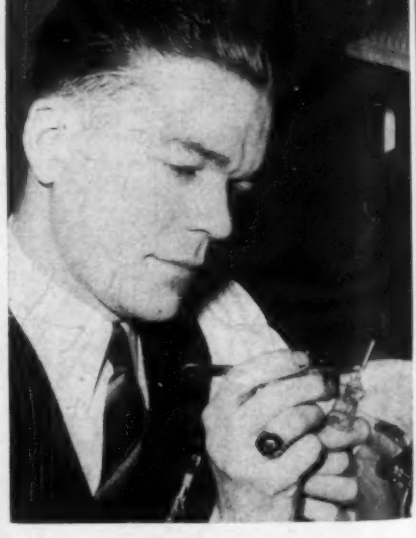


Closeup of a piece of uncooked spaghetti at work keeping the filament turns properly aligned. Current is sent through the filament to burn away the spaghetti after welding is completed

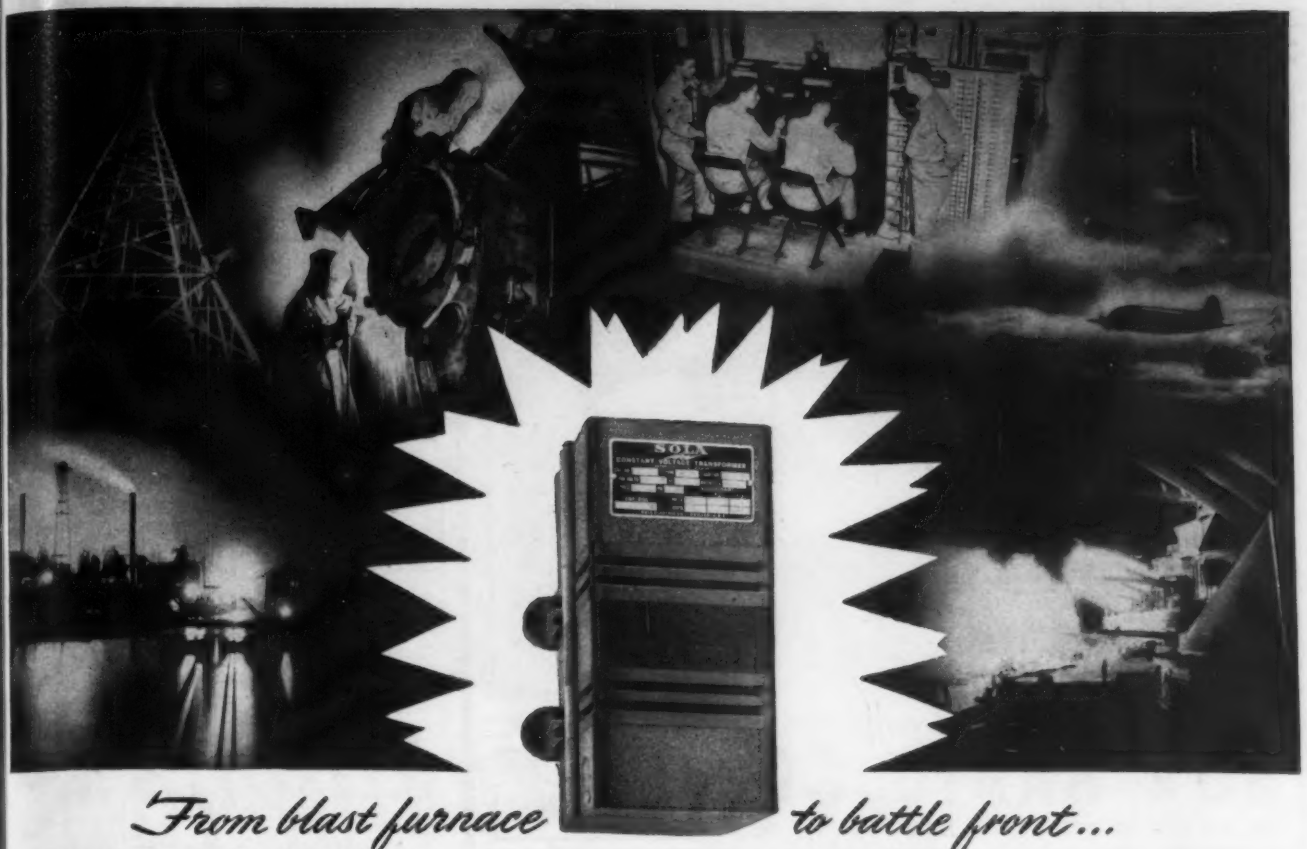
Production Merit has been recommended for the inventor.

Filaments for many tubes are made in the form of a small wire spring. Formerly a split steel rod was inserted in the filament coil for support as well as to keep the turns in accurate alignment while the coil was being welded to the rest of the mounting assembly. Since the coil tends to tighten around the steel insert after welding, the removal often requires realignment of the turns.

A small piece of spaghetti replaces the steel rod in the new method. After the filament is welded, current is passed through it to remove impurities in the metal. The heated filament burns up the spaghetti and eliminates the removal problem. The



William Hayes examines the spaghetti-supported filament he developed. The spaghetti is made to exact size by a special die



From blast furnace to battle front...

Constant Voltage guides the Tools of War

NEVER before in the history of warfare has precision production been so important as it is today. From the trigger group of an M-1 rifle to the fire control of a 16-inch battery, split-hair tolerances are demanded in millions of intricate munitions parts. Producing to uncompromising standards requires the finest type of machine tools ever designed—operated at a constant level of electric power.

But *constant voltage* is almost non-existent on today's overcrowded power lines. Wartime consumers are busier. Huge volumes of electrical energy are being intermittently used and released. Heavy sags and destructive surges inevitably occur. For that reason, manufacturers in every field are stabilizing power themselves with SOLA CONSTANT VOLTAGE TRANSFORMERS.

Sola "CVs" equalize voltage sags and surges, absorb variations as great as 30%, feed a controlled flow of power to machines. And they protect the *very life* of sensitive instruments and electronic tubes.

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Note to Industrial Executives: *Sola "CV" transformers are available in standard 10VA to 15KVA units. Special units to specification. Ask for bulletin DCV-74*

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whole operation is now done in about one quarter the time previously required.

In the initial experiments with the spaghetti, small pieces were placed on a lathe and machined to the correct diameter. Now the company that makes it turns out precision spaghetti with a die. Although the idea has only been applied to one size of filament, its use is planned for other sizes as soon as possible.

Free War Training Courses

TUITION-FREE COURSES are offered in the fields of radio engineering, electronic engineering, power systems, telephony, illumination engineering and mathematics at Illinois Institute of Technology in Chicago. To accommodate war plant workers on night shifts, some of the free classes are offered during the daytime. Although the program is primarily one of evening courses, elementary radio classes are conducted in the morning and afternoon.

A refresher course for graduate electrical engineers is given on Saturday mornings and one night weekly and is designed to cover modern applications of electronics and recent developments in power systems engineering. The only prerequisite for enrollment in the other courses is a high school education or the equivalent in industrial experience. A total of 3,453 men and women have already completed radio training courses at Illinois Tech.

New York University has an extensive program of 69 free evening courses for men and women and includes several new courses designed to meet the need for expansion in the air transportation field. Additional courses offered in the program are special courses in radio, electronics, VHF techniques, and aircraft electricity and communications.

Although all courses are open to women who meet the requirements for admission, the program includes several that are essentially basic in nature and designed primarily for women. Pre-engineering mathematics, technical drawing, production gaging and inspection, and a full time eight-week program in fundamentals of engineering are among the subjects.

More than 10,000 persons, including about 1,000 women, have been

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Photronic Cells now being made for war purposes only, hold many new possibilities for design engineers searching for better methods or new products for post-war markets.

The improved Type 3 photo-cell has a marked increase in sensitivity and can be produced in various outputs and various linearity factors, to meet specific circuit requirements. They can be matched in spectral sensitivity, too; to give practically the same spectral response curve throughout the color spectrum. And since the fatigue factor has been materially reduced, their response is more uniform, and far more rapid.

The development of the Type 3 is the result of continued research and experience in the processing of photo-cells dating back to 1930 . . . the year in which WESTON introduced the first American-made commercial cell of the barrier-layer type.

Type 3 Photronic Cells can be supplied in various styles and cases, as well as unmounted in a variety of shapes and sizes. Complete technical data, in booklet form, available to design engineers on request. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

*PHOTRONIC—*A registered trademark designating the photoelectric cells and photoelectric devices manufactured exclusively by the Weston Electrical Instrument Corp.*

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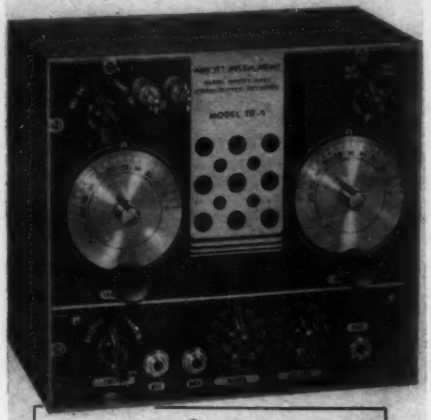
FOR OVER 54 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

FASTER
than rabbits

Spurred by war demands, ideas are breeding faster than rabbits. We've done a lot of development, too. Advancements in theory and in the design of auxiliary products have paved the way for better ABBOTT ultra-high-frequency transmitting and receiving sets. Right now, however, we are concentrating on the job that needs our immediate attention . . . the war job!



Doing a good job, wherever it is now being used, is the ABBOTT Model TR-4 . . . a standard, compact and efficient ultra-high-frequency transmitter and receiver.

Give a pint of your blood today.
Save a soldier's life tomorrow.

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enrolled in the various courses since the inception of the program in 1940. Requirements for admission vary, but academic high school graduation is required in all courses. In addition the applicant must be employable at the kind of work toward which the training is directed.

Since many other colleges, universities and high schools throughout the country are offering courses similar to these and also financed by the United States Office of Education through the ESMWT program, it is suggested that local schools be contacted by individuals interested in technical courses of any kind, ranging from elementary theory to the study of Maxwell's equations for VHF design.

Electronic Desk Tests Cathode-ray Tubes

ELECTRONIC TESTING DESKS are being used in the Du Mont Laboratories for routine production checkup of cathode-ray tubes by girls. Although the present production of such tubes runs into thousands, each tube must still be individually tested since spot tests or percentage tests mean little or nothing when dealing with such critical devices.

Production testing of cathode-ray tubes at a special desk that contains the necessary power supplies, controls and meters

Several of the test desks are installed in the Du Mont plant to provide mass testing. Each is composed of a steel cabinet, similar to a flat top desk, and contains an inclined platform to support the cathode-ray tubes under test. A group of meters is mounted beneath the front of the platform for the necessary readings.

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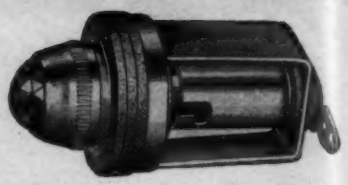

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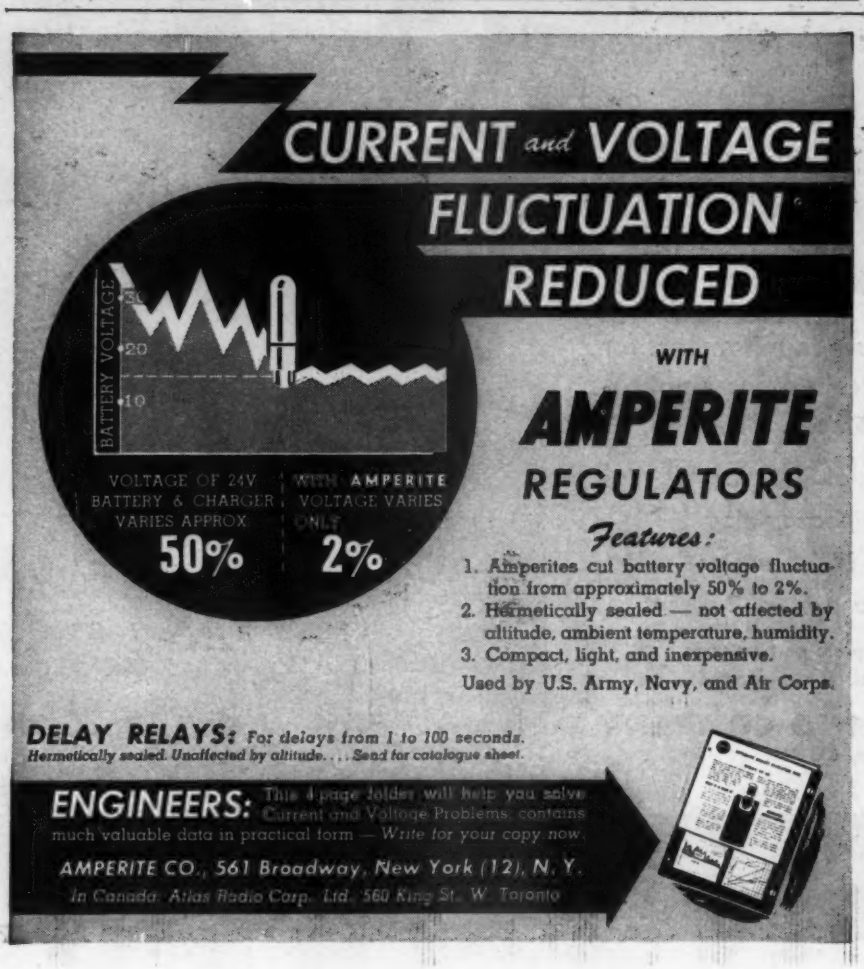
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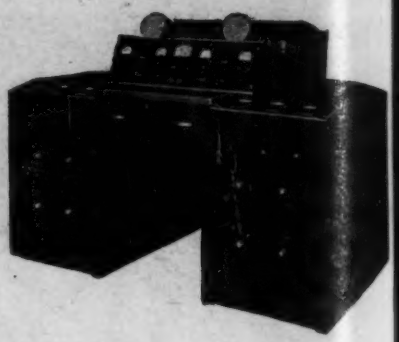

The test desk resembles a control console used by broadcast stations and provides quick testing of cathode-ray tubes

More meters are mounted on both sides of the writing space on top of the desk.

Testing of different tube types requires a large range of voltages from the power supply. These are provided by switches and controls located where desk drawers are normally placed. After these are adjusted the operator checks brilliance, focus, leakage resistance, and other characteristics, and enters the readings on an inspection sheet for each tube. Special notations are made on the face of the tube with a grease pencil.

Dr. Pierce Awarded Franklin Medal

THE HIGHEST AWARD given by the Franklin Institute of Philadelphia was recently awarded by that society to Dr. George Washington Pierce, pioneer radio physicist. Dr. Pierce has occupied the chairs of Rumford Professor of Physics and Gordon McKay Professor of Electrical Communication over a long period of years at Harvard, and his courses in radio telegraphy and electric oscillations were the first to be given in this country.

Dr. Pierce also received a Certificate of Honorary Membership which accompanies the Medal, after being introduced by Stuart Ballantine, who reviewed some of the contributions Dr. Pierce has made to the art. These include:

Early work on the rectifying properties of crystal detectors; invention of a mercury vapor tube which was the prototype of the thyratron, later developed by A. W. Hull; mathematical calculation of radiation from radio antennas; work on electric filters and compensators for underwater signalling and submarine de-

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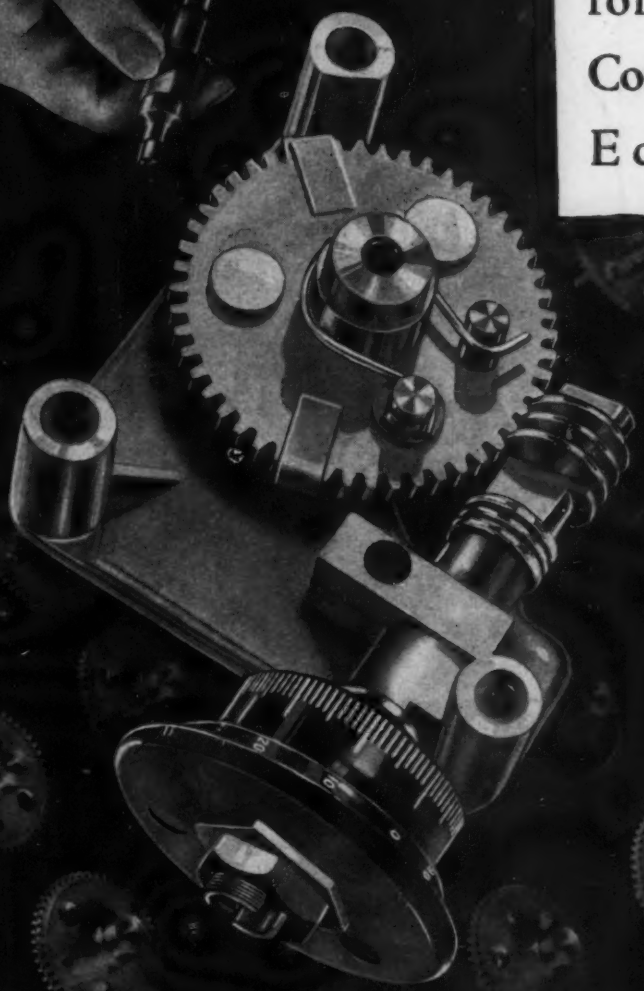
Precision Units and Controls for Radio and Communication Equipment



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WIRE PRODUCTS Jelliff SINCE 1880

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SOUTHPORT, CONN.

tection. Perhaps his most widely known and used invention is the quartz piezoelectric oscillator, widely used in radio transmitters. He also utilized the magnetostriction effect in nickel and nichrome for the same purpose, this having important applications in submarine detection and signaling.

After expressing his heartfelt gratitude to the members of the Society, Dr. Pierce addressed the gathering on the subject "Songs of Insects." He described an electronic mixer that he has developed as a summer pastime, by which the inaudible high-frequency sounds produced by insects are transposed to an audible frequency for observation. He concluded his remarks with an interesting reference to the successful education of a katydid, accomplished by playing back a record of his song, to produce five pulses of sound instead of the usual two.

Under-Helmet Headset

A NEW HEADSET, adopted by the Signal Corps, can be worn under steel helmets that fit far down over the sides of the head. The larger headsets forced communications men to go into battle zones bareheaded.

Each receiver unit has a soft plug that fits into the outer orifice of the ear in much the same manner that hearing aids are used by civilians. Besides permitting the use of the helmet for protection, the plug forms

A communications man dons one of the new headsets that contains inserts fitting into the ear channels. Strain on the cord is relieved by a clip on the soldier's shirt

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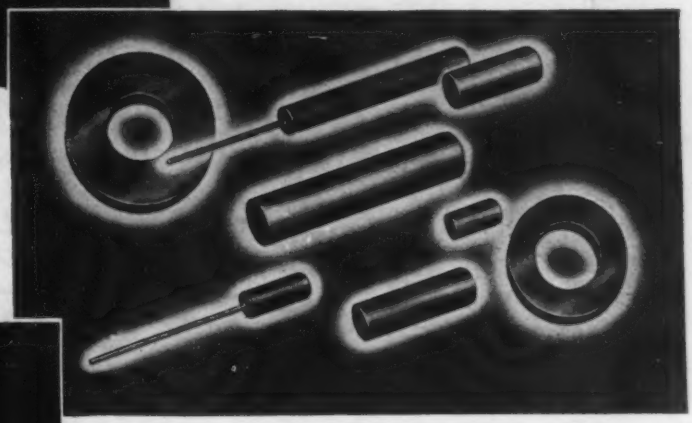
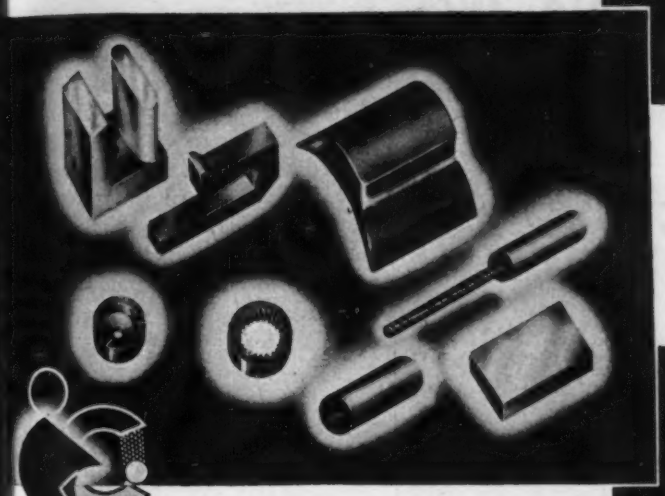
IRON CORES

Recent Stackpole developments include molded Iron Cores for radio equipment operating at frequencies as high as 175 megacycles. Other Stackpole Iron Cores are available in a variety of grades and sizes for frequencies up to 50 megacycles. Molded from metal powders to match your specifications.





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CONTACTS

Stackpole offers suitable contacts for almost every application—from the various silver compositions to dozens of special alloys. Equally important is the Stackpole engineering service that not only helps you select the right contacts, but, if necessary, adapt your equipment to utilize them most efficiently.

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Builders of Precision Radio Communications Equipment
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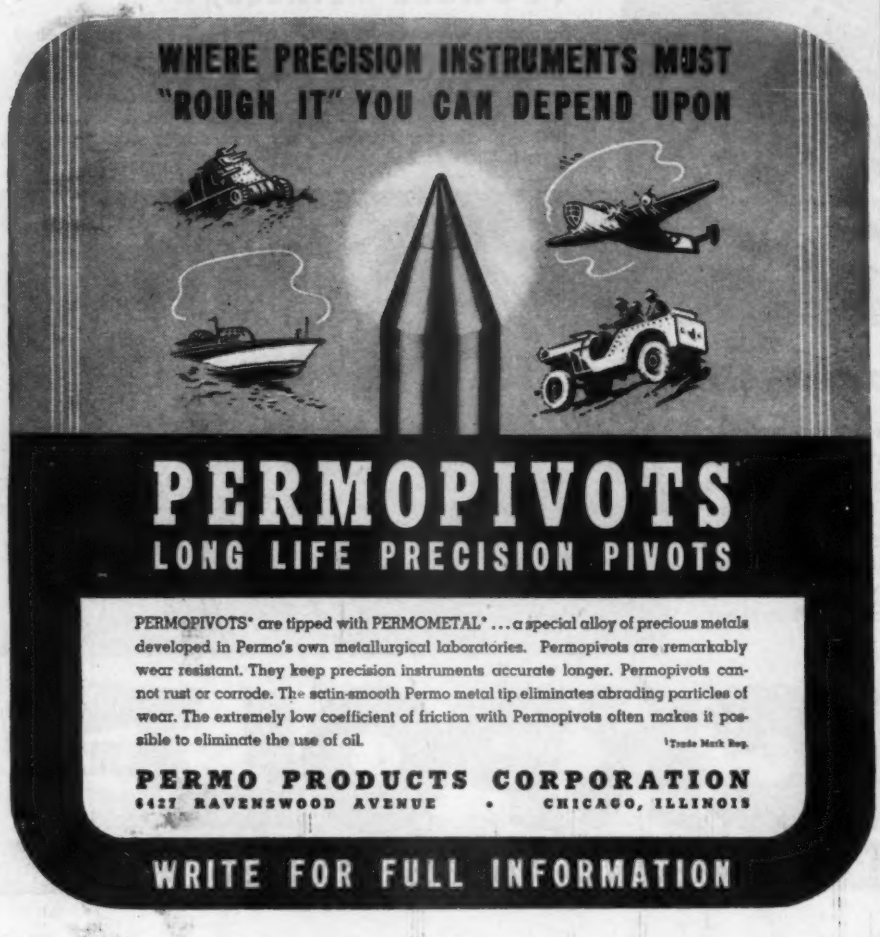

WHERE PRECISION INSTRUMENTS MUST
"ROUGH IT" YOU CAN DEPEND UPON
PERMOPIVOTS
LONG LIFE PRECISION PIVOTS
PERMOPIVOTS* are tipped with PERMOMETAL* ... a special alloy of precious metals developed in Permo's own metallurgical laboratories. Permopivots are remarkably wear resistant. They keep precision instruments accurate longer. Permopivots cannot rust or corrode. The satin-smooth Permo metal tip eliminates abrading particles of wear. The extremely low coefficient of friction with Permopivots often makes it possible to eliminate the use of oil.
*Trade Mark Reg.
PERMO PRODUCTS CORPORATION
6427 RAVENSWOOD AVENUE • CHICAGO, ILLINOIS
WRITE FOR FULL INFORMATION

Protection from head wounds is provide by GI helmets worn over new type hea sets made by Western Electric

a seal that helps keep out batt noises. Since the sound is admitt directly to the ear channel, hig sensitivity and fidelity of tone a provided.

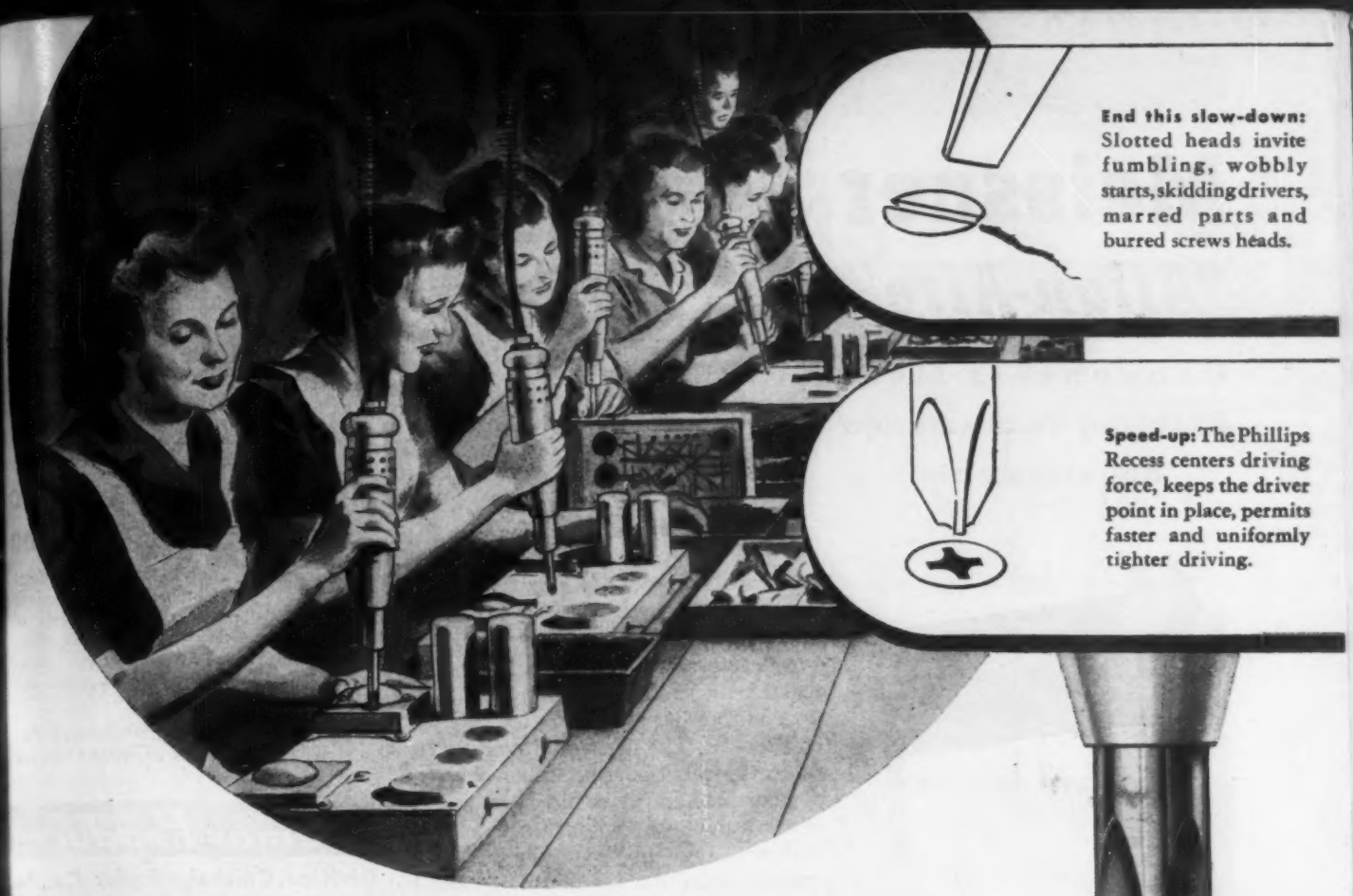
The ear inserts are made of ne prene and are said to be better th rubber. New plugs are issued each wearer for sanitation.

A clothes clip on the cord is a tached to the operator's shirt to ke strain on the cord from being co ducted to the receiver terminals. T cord also contains a transformer th matches any high-impedance outp circuit.

New Calls for FM Stations

A NEW SYSTEM, using call letters i stead of the present letter and n meral arrangement, has been adopte by the FCC for FM broadcast st tions. About 4,000 four-letter cal are available for assignment and l censees of FM stations may reque the combination of letters they d sire. In cases where a licensee al operates a standard broadcast stati in the same city he has the choice using the standard station call wi the suffix "FM", or a new four-lett call.

The Commission calls attention the fact that all three-letter calls a already assigned. The number four-letter calls appears ample f all additional standard, FM, co mercial television, and nonbroadca stations for some time to come. Ca



End this slow-down: Slotted heads invite fumbling, wobbly starts, skidding drivers, marred parts and burred screws heads.

Speed-up: The Phillips Recess centers driving force, keeps the driver point in place, permits faster and uniformly tighter driving.

Capture EXTRA PRODUCTION with Your Screw Driving Army

PHILLIPS SCREWS DRIVE TWICE AS FAST

Don't just *worry* about lagging production . . . *do something* about it! Boost your output by providing your assembly line with Phillips Screws – the modern speed-screw with the scientifically engineered Recessed Head! The Phillips driver automatically centers in the screw head, utilizes turning power rather than head-on pressure, eliminates the troubles that slow-up driving . . . wobbles, skids, burred screw heads. The result is speedier assembly . . . as much as 50% in some plants.

The skid-proof feature of the Phillips Recess further prevents marred parts and driver-slashed hands. Freed from fear, old timers and newcomers alike can concentrate on fast, faultless driving. Power and spiral drivers can be used to advantage. Switch to Phillips Screws and see how your screw driving army chalks up new assembly records.

Compare the cost of driving Phillips versus slotted head screws. You'll find that it actually costs less to have the many advantages of the Phillips Recess!

KEY TO FASTENING SPEED AND ECONOMY

The Phillips Recessed Head was scientifically engineered to afford:

Fast Starting – Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.

Faster Driving – Spiral and power driving are made practical. Driver won't slip out of recess to injure workers or spoil material. (Average time saving is 50%.)

Easier Driving – Turning power is fully utilized by automatic centering of driver in screw head. Workers maintain speed without tiring.

Better Fastenings – Screws are set-up uniformly tight, without burring or breaking heads. A stronger, neater job results.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

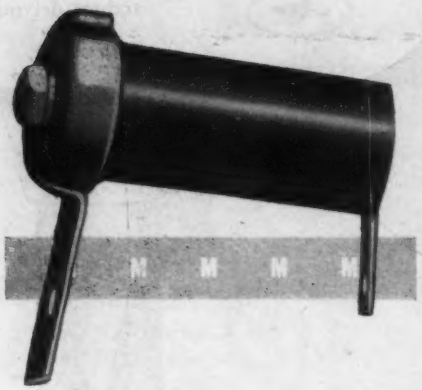
21 SOURCES

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

Meissner

"Align-Aire"

Condensers Meet Exacting Performance Requirements!



Meissner "Align-Aire" (midget) units are now encased in the newly developed, low loss, bakelite (number 16444) and occupy extremely small space . . . only 7/16" in diameter and 1⅛" long . . . they are an ideal trimmer for high frequency coils. Midget "Align-Aire" Condensers are exceptionally stable. Capacity range 1 to 12 mmfd.

Many years of engineering research developed the Meissner "Align-Aire" Condensers to meet the exacting performance requirements of high frequency circuits.

Samples sent upon request.

AVAILABLE ONLY ON PRIORITIES

"PRECISION-BUILT ELECTRONIC PRODUCTS"

Meissner
MT. CARMEL, ILLINOIS

beginning with the letter W are assigned to stations east of the Mississippi River, while calls beginning with the letter K are assigned to stations west of the Mississippi and in the territories. About 1100 "W" calls and 2,900 "K" calls are still unassigned.

In the old letter-numeral system, the first letter of an FM call indicated the geographical position of the station in regard to the Mississippi, while the number designated the frequency of the station. The last letters were used to show the city in which the station was located.

The Commission's decision to discard these combination calls for FM stations came about because of several disadvantages and inherent limitations in the system and was based upon the past experience of FM broadcasters and the advisability of making the change at this time when transmitter construction is halted by the war. The licensees found that the letter-numeral call is somewhat cumbersome and does not meet with general public acceptance. In addition a change in frequency of the station involved a change in the call with consequent confusion. It was also felt that as more and more FM broadcast stations were licensed it would be increasingly difficult to identify a station with a particular city by means of the initial letters of the city.

Machining Standards for Glass-Bonded Mica

THE PROCEDURE FOR machining glass-bonded mica radio insulators and recommended practice for the handling and design of such insulators is contained in the recently approved American War Standard C75.6-1943.

The main feature of the standard is that it provides engineers and draftsmen with specific information about the machining of glass-bonded mica items. How corners should be cut, how holes should be tapped, and what thicknesses are available, are some of the questions answered by the design data included. Informative diagrams such as that shown in the illustration indicate the proper manner of working the material.

No standard shapes or type designations are set up in the standard.

PREMAX

Antennas Designed Fo Wartime Communication

Premax is supplying Tubular Metal Antennas in many different designs and with many different types of Mountings. They are doing excellent service in the Armed Forces, insuring communications under most trying conditions.

Send for sketches of Standard Designs . . . or details of special designs if required.

Premax Products
Division Chisholm-Ryder Co., Inc
4402 Highland Ave., Niagara Falls, N.

University
LOUDSPEAKERS

REFLEX SPEAKERS are now the ACCEPTED STANDARD for all WAR USE

- EVERY REFLEX in the UNIVERSITY LINE is the result of YEARS of RESEARCH
- EVERY REFLEX in the UNIVERSITY LINE has a vital part to play in the WAR PROGRAM
- There are OVER 50 SPEAKERS in the UNIVERSITY LINE

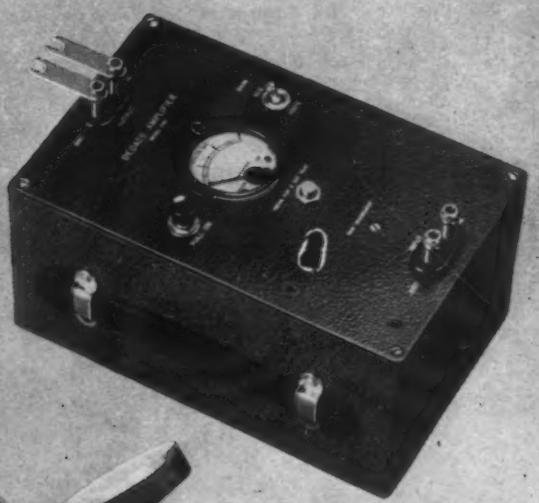
Submit your special problems direct to our engineering department.

UNIVERSITY
225 VARICK STREET N. Y. C.

0.00002 to 10,000 VOLTS!

BALLANTINE
ELECTRONIC
AC VOLTMETER
AND ACCESSORIES

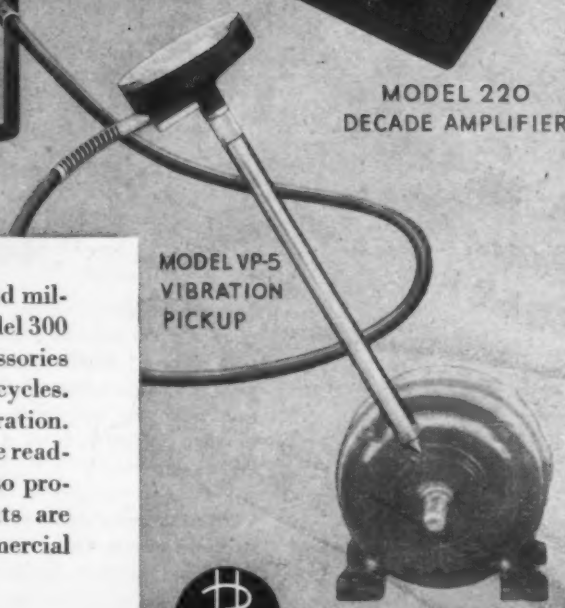
MODEL 300
ELECTRONIC
VOLTMETER



MODEL 220
DECADE AMPLIFIER

MODEL 505
ARTIFICIAL EAR

MODEL 402
MULTIPLIER



MODEL VP-5
VIBRATION
PICKUP

This enormous range of voltages—five hundred million to one—is accurately covered by our Model 300 Electronic Voltmeter and some of the accessories shown above. Frequency range 10 to 150,000 cycles. Accuracy 2% over most of the range. AC operation. Five decade ranges with logarithmic scale make readings especially easy. Uniform decibel scale also provided. Over a thousand of these instruments are giving excellent service in Government, commercial and university laboratories and factories.

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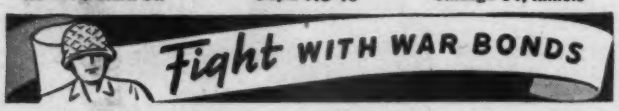
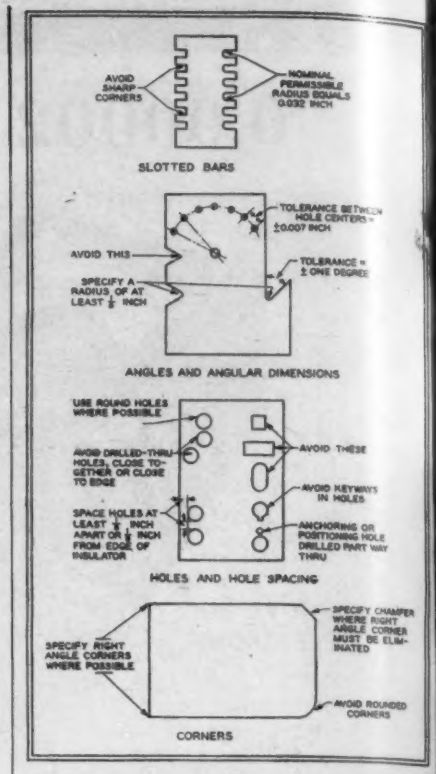



AVOID SHARP CORNERS
NOMINAL PERMISSIBLE RADIUS EQUALS 0.032 INCH
SLOTTED BARS
TOLERANCE BETWEEN HOLE CENTERS ± 0.007 INCH
AVOID THIS
TOLERANCE ± ONE DEGREE
SPECIFY A RADIUS OF AT LEAST ⅛ INCH
ANGLES AND ANGULAR DIMENSIONS
USE ROUND HOLES WHERE POSSIBLE
AVOID THESE
AVOID DRILLED-THRU HOLES, CLOSE TOGETHER OR CLOSE TO EDGE
AVOID KEYWAYS IN HOLES
SPACE HOLES AT LEAST ⅛ INCH APART OR ⅛ INCH FROM EDGE OF INSULATOR
ANCHORING OR POSITIONING HOLE DRILLED PART WAY THRU
HOLES AND HOLE SPACING
SPECIFY CHAMFER WHERE RIGHT ANGLE CORNER MUST BE ELIMINATED
SPECIFY RIGHT ANGLE CORNERS WHERE POSSIBLE
AVOID ROUNDED CORNERS
CORNERS

Examples of the diagrams used in the new American War Standard for machining glass-bonded mica

It differs in this respect from other American War Standards.

It is expected that the standard will be used by radio equipment manufacturers and the Armed Forces in designing new equipment and replacement parts to comply with the specifications for greater interchangeability.

The new standard was prepared through the coordinated efforts of the representatives of industry and the Armed Forces at the request of the War Production Board. Copies of the new War Standard, Glass-Bonded Mica Radio Insulators (C75.6-1943), may be obtained from the American Standards Association, 29 West 39th St., New York, at 25 cents each.

Suggested Wire Standards

ALTHOUGH THE MECHANICAL industry has been hampered by the use of several series of gage numbers to designate the thickness of metal sheets, the electrical industry has been relatively free of this complication because of the widespread use of the American Wire Gauge.

The American Standards Association has set up a standard for pre-

WAR-TESTED

FOR SUPERIOR *Peace-Time* PERFORMANCE

In the middle of battle . . . through the boom of guns and the roar of planes . . . when every man and piece of equipment are extended to the utmost . . . radio provides the vital means of communication for our fighting forces. Under these grueling conditions, Sentinel-built equipment is proving its dependability.

In the post-war battle for sales and profits, this war-tested dependability and performance . . . plus up-to-the-minute design . . . will be powerful merchandising weapons for Sentinel dealers.

SENTINEL RADIO CORPORATION
2020 Ridge Avenue, Evanston, Ill.

Quality Since 1920

Sentinel RADIO

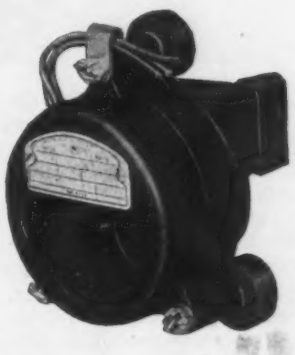
WEIGHT REDUCTION PROBLEMS?

In designing radios for combat service, every ounce counts. Weight reduction is not only an engineering problem—it becomes a matter of fighting efficiency. Westinghouse engineers have co-operated with many designers to work out a variety of solutions, of which the accompanying illustrations are typical examples.

Perhaps these are directly applicable to your problem; or it may be that yours is completely different. In either case, trained and experienced Westinghouse representatives are ready to help you; call them today. Westinghouse Electric & Manufacturing Company, Dept. 7-N, East Pittsburgh, Pennsylvania. J-94565

*Registered Trade-mark Westinghouse Elec. & Mfg. Co.

Hipersil*, the new Westinghouse magnetic steel for transformer cores, increases flux-carrying capacity ½ and reduces weight 30 to 50%.



For aircraft and airborne radio, blower and motor combined for maximum air circulation in a weight-saving magnesium housing.

Inerteen capacitors deliver more microfarads per ounce.

INSULATION

Tuffernell, Glasweve and mica insulating materials permit high operating temperatures and consequent savings in weight.

Westinghouse

PLANTS IN 25 CITIES...OFFICES EVERYWHERE

ACCURATE

UNFAILING accuracy is one of the many features of the new General Electric line of ELECTRONIC MEASURING INSTRUMENTS. Designed in the famous G-E electronics laboratories, this line offers a wide choice of compact apparatus for service, maintenance and research.

G-E unimeters, capacitometers, audio oscillators, wide band oscilloscopes, square wave generators, signal generators, power supply units —all give you dependable service in measuring electronic circuits and component parts.

These sturdy, shock-resistant units are now in production primarily for the Armed Forces. But they may be purchased on a priority if you are engaged in war work. After the war, of course, the full line will again be available to everybody. . . . *Electronics Department, General Electric, Schenectady, N. Y.*

• We invite your inquiry for G-E electronic measuring equipment made to meet your specific requirements

FREE CATALOG

ELECTRONICS DEPARTMENT
GENERAL ELECTRIC CO.
Schenectady, N. Y.

Please send, without obligation to me, the General Electric Measuring Instrument Catalog, E-1 (loose-leaf), for my information and files.

*Name*_____

*Company*_____

*Address*_____

GENERAL ELECTRIC
177-82
Electronic Measuring Instruments

ferred thicknesses of flat metals, sponsored by the American Society of Mechanical Engineers and the Society of Automotive Engineers. This has been followed by a suggested standard of preferred sizes for bare and metallic coated round wire in which the following sizes in inches are proposed:

PREFERRED SIZES FOR ROUND WIRE

.....	0.344	0.180	0.090	0.045	0.022	0.011	0.0056		
.....	0.312	0.160	0.080	0.040	0.020	0.010	0.0050	0.0025	0.0012
.....	0.281	0.140	0.071	0.036	0.018	0.009	0.0045		
0.500	0.250	0.125	0.063	0.032	0.016	0.008	0.0040	0.0020	0.0010
0.438	0.224	0.112	0.056	0.028	0.014	0.007			
0.375	0.200	0.100	0.050	0.025	0.012	0.0063	0.0032	0.0016	0.0008

The proposal has been distributed to industry for criticism and comment. Of 139 replies received, 74 indicated approval or were noncommittal and 65 offered comments and suggestions. The principal opposition to the adoption of the proposed standard has come almost exclusively from users of copper wire for electrical purposes, whose design and technical data are all in terms of the American Wire Gauge.

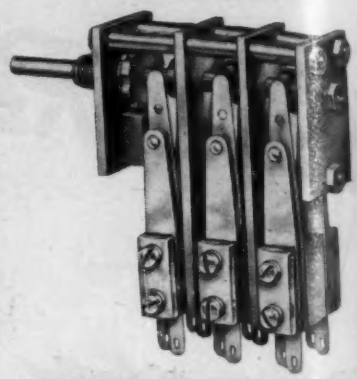
It is suggested by the ASME, in the August 1943 issue of *Mechanical Engineering*, that a careful study be made of the proposed system of sizes to determine if it can be brought into line with the present deeply entrenched usage in the electrical industry. There are some indications that this can be done, but the project has been tabled for the duration of the war to allow correspondence, discussion, and comments from industry.

There is much less standardization in the mechanical uses of wire than there is in electrical applications, and a great deal may be gained by that industry by the general acceptance of a uniform system of numbers based on the inch unit of measure.

—⟡—

PAPER SHORTAGES forced the morning newspaper in Beaumont, Texas to ask 5000 subscribers to drop their subscriptions. Several hundred defense workers offered to do so if they could get an early morning newscast, so station KRIC volunteered with a 15-minute roundup of AP news at 6 a.m., when the morning shift is getting ready for work and the night shift is coming home.

IT'S NEW



A ROTARY SWITCH THAT'S DIFFERENT — AND BETTER

When wiring, contact assemblies can be removed from frame by *a single bolt*. When mounting, *a single hole* only is required in panel. Available in single and multiple units, and up to six switch positions. Contact rating, 10 amps. 125 V.A.C.; 2 amps. 125 V.D.C. Breakdown rating, 2500 volts D.C. between springs; 4500 volts D.C. between springs and frame. For further details write to

GENERAL CONTROL COMPANY
Windsor St. Cambridge, Mass.

110-VOLTS A.C.
from DIRECT CURRENT

with KATOLIGHT ROTARY KONVERTERS for operating radio and electronic equipment, moving picture projectors, sound apparatus, A.C. appliances, etc.

225 VOLT-
AMPERE CONVERTER

Available in sizes 80 through 2500 volt-amperes, 1800 and 3600 r.p.m., ball bearing designs. Furnished standard 110-volt 60 cycle A.C. from 32,110 or 220-volts direct current. Quiet in operation. Can be furnished with special filtering equipment for sensitive radio work.

PIONEERS IN THE BUILDING OF SMALL ROTARY CONVERTERS

At present Kato's entire production must be directed to furnishing converters on high priority orders. Wire us if you need this kind of equipment for orders.

Also manufacturers of A.C. and D.C. generators ranging from 350 watts through 25 K.W.; power plants; Frequency changers; high frequency generators; and Motor Generator Sets.

KATOLIGHT COMPANY
62 ELM ST. MANKATO, MINN.

from Every Angle **THEY CAN DEPEND ON**

The Type 27

SUPER AIRCRAFT RELAY

G-M

Originally designed for combat aerobatics . . . where strain and stress impose conditions unknown to pre-war relays . . . the Type 27 Super Aircraft Relay offers numerous advantages for a wide range of other uses.

Double trussed box frame construction provides rugged strength and rigidity . . . Measurements are 1½" x 1⅝" x 1⅞" and weight but 5 ounces. The type 27 SPDT double make—double break in 2 pole construction can withstand in excess of 15g without a flicker . . . has a 60 gram contact pressure (double make—double break) and a 10 ampere contact capacity at 30 volts d.c. (100 ampere inrush). Nominal coil voltage is 12 volts d.c. with a pickup of 6.5 volts (.61 watt) at 20° C. Coil wattage at 12 volts d.c. is 2.1 watts at 20° C. Temperature range is from −40 to + 90° C.

Free samples of this relay are available to manufacturers on request if accompanied by a priority of AA-4 or better. Write or wire today requesting relay No. 12723.

VISITRON PHOTOTUBES

are available in quantity in numerous sizes. Made by G-M, pioneer in development and manufacture of quality phototubes.

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Fabricated parts for electronic tube and condenser manufacturers—including discs, bridges, supports, stampings in any shape or form, condenser films, etc. We are serving hundreds of leading companies since 1917. Special attention has been paid to radio tube and component manufacturers since the early days of the radio industry.

Our complete manufacturing facilities, experience and the quick understanding of our customers' problems, blend to make our service invaluable to an increasing number of new clients.

FOR EVERY RADIO ELECTRICAL AND ELECTRONIC USE

May we quote on your requirements or discuss your mica problems with you?

FORD RADIO & MICA CORP.

Joseph J. Long, President

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Established 1917 • *Telephone:* Windsor 9-8300

Rochester Fall Meeting

November 8 and 9, 1943
Sagamore Hotel
Rochester, New York

MONDAY, NOVEMBER 8

9:30 A.M.—12:30 P.M.

Technical Session
Review of the problem:

"Demountable Versus Sealed-off Tubes," by I. E. Mouromtseff, Westinghouse Electric & Manufacturing Company

"Recent Advances In Klystron Theory," by W. W. Hansen, Sperry Gyroscope Company

2:00 P.M.

Technical Session

"The Design of I. F. Transformers for Frequency Modulation Receivers," by William H. Parker, Jr., Stromberg-Carlson Company

"Vacuum Capacitors," by George H. Floyd, General Electric Company

4:00 P.M.

Committee Meetings

8:15 P.M.

Technical Session

"The Signal Corps Looks to the Engineer," by Lt. Col. Kenneth D. Johnson, U. S. Army Signal Corps

TUESDAY, NOVEMBER 9

9:30 A.M.

Technical Session

Message of RMA Director of Engineering Dr. W. R. G. Baker

"Operating Characteristics of Ceramic Dielectrics with Constants over 1000," by R. B. Gray, Erie Resistor Corporation

"A Chamber of Commerce War Research Committee," by K. C. D. Hickman, Distillation Products, Inc.

2:00 P.M.

Technical Session

Report of RMA Data Bureau, by L. C. F. Horle

"New Low Loss Ceramic Insulation," by Ralston Russell, Jr. and L. J. Berberich, Westinghouse Electric & Manufacturing Company

"Design of I.F. Systems," by J. E. Maynard, General Electric Company

4:00 P.M.

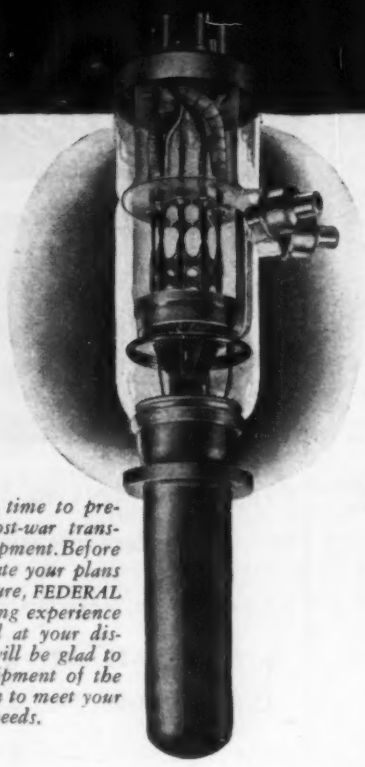
Committee Meetings

6:00 P.M.

Banquet

Toastmaster—R. M. Wise

An exhibit of the U. S. Army Signal Corps equipment will be a feature of both days



...ow is the time to pre-...re for post-war trans-...itting equipment. Before ...u formulate your plans ...r the future, FEDERAL ...aces its long experience ...this field at your dis-...sal and will be glad to ...scuss equipment of the ...best design to meet your ...dividual needs.

FEDERAL is devoting its major energies in the manufacture of transmitting and rectifying tubes to the war effort, turning out great quantities of essential types and sizes for vital military purposes.

Into each of its tubes goes the result of FEDERAL'S leadership in construction and design, in the use of rare metals improved in purity and mechanical properties, and in workmanship that represents the last word in tube building — all of which assure uniformity of electrical characteristics and longer life in performance.

These advantages have long been recognized and that is why many of the leading broadcast stations in the United States are equipped with FEDERAL tubes.

FEDERAL is, and always has been, in the vanguard of tube development and manufacture. Behind its facilities and outstanding achievements are some of the world's best engineering minds and technical experience. This leadership and ability are available to broadcast stations in meeting their tube requirements.

Federal Telephone and Radio Corporation

NEWARK, NEW JERSEY

AN IT&T ASSOCIATE

"...IN-RES-CO resistors have that essential designability"

★ Manufacturers of sensitive equipment for industrial and military needs, have found the integrating advantages of IN-RES-CO resistors of particular importance where space is limited. These exceedingly compact components offer dependability under severe atmospheric and electrical conditions because each must pass a voltage breakdown overload test of 100% their rated working voltage. Literature will be sent promptly on request without obligation.

TYPE RL (at left), ½ Watt, Non-inductive, Standard tolerance ½%, Maximum resistance 500,000 ohms, Size ½" diam. x ½" high.

TYPE SL (at right) 1 Watt, Non-inductive, Standard tolerance ½%, Maximum resistance 1 Meg-ohm, Size ½" diam. x 15/16" high.

IN-RES-CO

INSTRUMENT RESISTORS COMPANY

25 AMITY ST., LITTLE FALLS, N. J.

Radio Business News

A DIFFERENTIAL PRESSURE gage which cuts down testing time of (censored) equipment from 4 hours to 7½ minutes won a WPB War Production certificate for Francis E. Pratt, instrument laboratory engineer for Stromberg-Carlson. The WPB reports that the Office of the Chief Signal Officer regards the device as a definite contribution to the kind of aircraft radio equipment that is not used for navigation or communication.

UNPRECEDENTED EXPORT complications face the Export Committee of the RMA, according to Walter A. Coogan, director of International Division of Sylvania Electric Products Inc., re-appointed chairman of the committee. "It is not difficult to obtain orders today," he explained. "Our most pressing problems are those connected with obtaining licenses from OEW and priority ratings from WPB. The shortage of shipping space has eased up considerably, and space is now available to most countries."

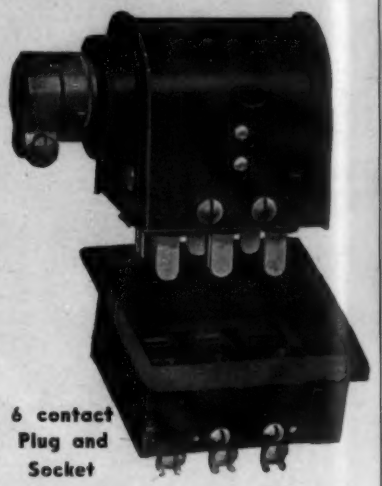
RESEARCH ENTERPRISE LIMITED, a Canadian government-owned company that employs 6,800 people, is working on orders for radio and optical equipment totaling more than 130 million dollars. Output of the radio industry in that country has expanded sixteen-fold since the beginning of the war and has caused the development of three new industries for production of dynamotors, ceramic insulators and crystals.

CBS WILL CONSTRUCT a new international broadcast station at Wayne, N. J., to be added to the new network of short-wave transmitters being used by the OWI Overseas Division to beam American news and programs to all parts of the world. The station will have two short-wave transmitters to furnish two-frequency coverage. The construction cost is announced as $476,150.

ANTICIPATING the resumption of domestic radio production, the Radio Manufacturers Association has set up a special committee for post-war planning that includes many prominent executives of the industry.

The committee, headed by R. C. Cosgrove, vice-president and general manager of the Crosley Corp., will correlate their work on the economic

JONES 500 SERIES PLUGS and SOCKETS



6 contact Plug and Socket

5000 volts and 25 amperes. Fulfills every electrical and mechanical requirement. Polarized to prevent incorrect connections. Easy to wire. Sizes: 2, 4, 6, 8, 10 and 12 contacts. Thousands of uses. Write for Bulletin 500 today.

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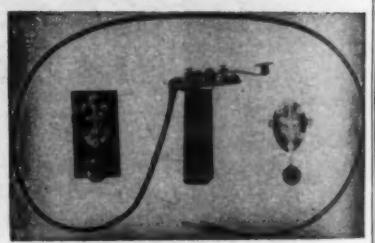
TELEGRAPH and RADIO KEYS



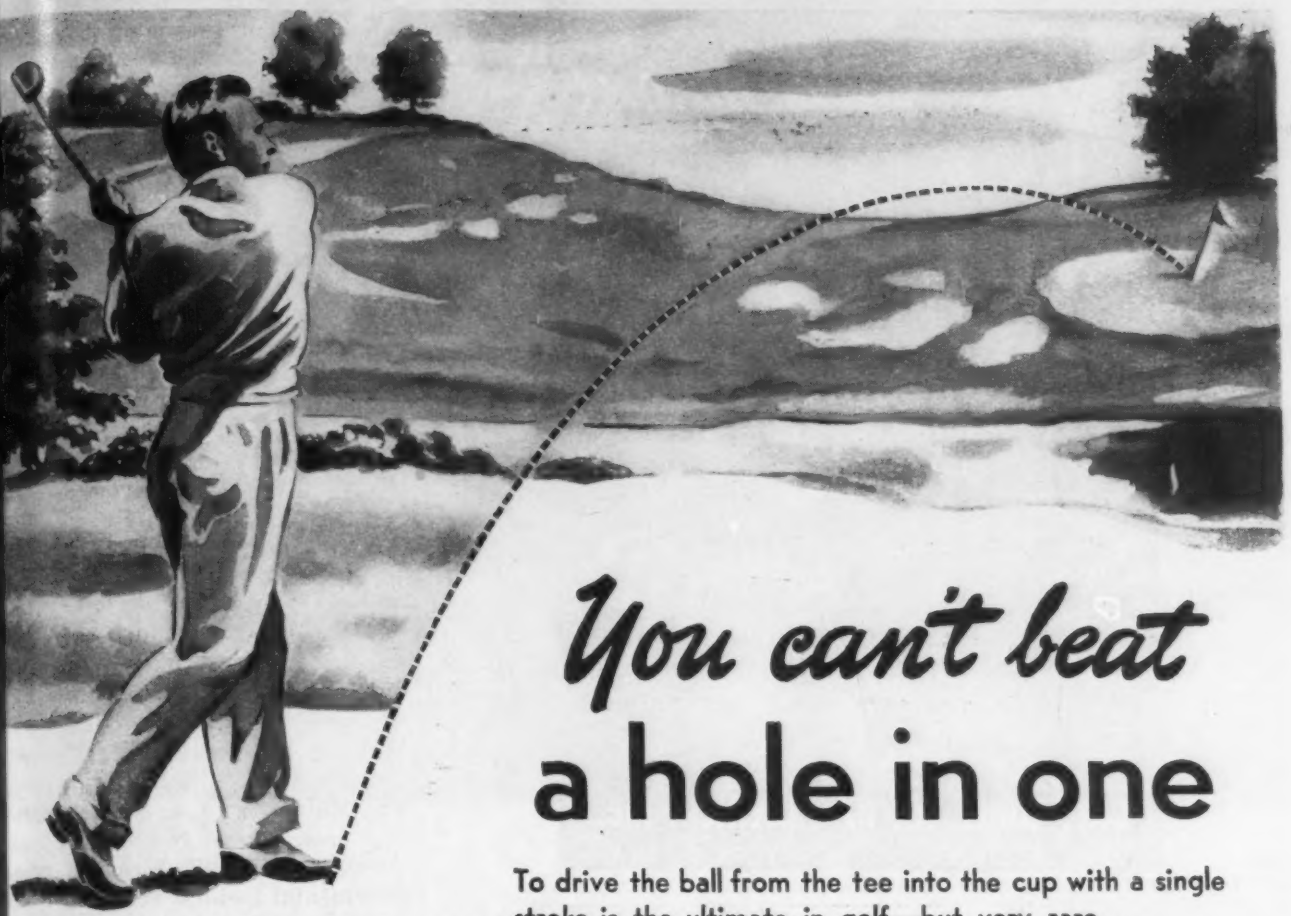
Telegraph Keys to Signal Corps Specifications

Types now in production include

J-12, J-18, J-28, J-29, J-30
J-31, J-37, J-38, J-40, J-41-A
J-44, J-45, J-46, J-47, J-48

Quotations upon request

THE WINSLOW COMPANY
INCORPORATED
9 Liberty Street, Newark, N. J.



You can't beat a hole in one

To drive the ball from the tee into the cup with a single stroke is the ultimate in golf—but very rare.

To transmit mechanical power—or remote control—between two points **with a single part** is the ultimate in design—but not at all rare—for you can do it every time with an S. S. White Flexible Shaft—regardless of the relative locations of the points which must be connected or of obstacles in the path between them.

That's why electronic equipment designers should consider S. S. White Flexible Shafts* whenever power drive or remote control problems come up—for their use simplifies manufacturing, speeds production, cuts costs.

S. S. WHITE FLEXIBLE SHAFT

S. S. White Flexible Shafts come in a wide range of diameters and physical characteristics, in both the power drive and remote control types. Long years of use in aircraft, motor vehicles, radio and many other fields have verified their excellence and unfailing dependability.

ASK FOR THESE BULLETINS

BULLETIN 1238—Power Drive Flexible Shafts.
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The S. S. White Dental Mfg. Co.

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Write for new 24-page Dialco Catalogue .. now!
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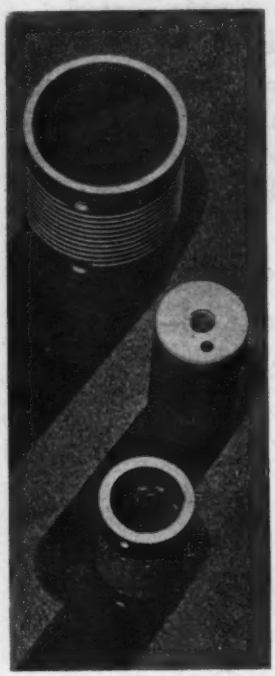

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Just one of several ways by which this essential product is made at STAR, where high pressure hydraulic extrusion presses insure uniform density and dimensions in the finished piece.

The STAR PORCELAIN COMPANY
ELECTRONICS DEPT. TRENTON, N. J.

problems of the industry with that of the technical planning agency organized by the RMA and the IRE.

"Through the organization of subcommittees or panels, the committee will deal with such subjects as: liaison planning with government and industry agencies; reconversion to civilian production; public relations, including promotion and advertising; distribution problems; war contract termination; war inventory disposal; problems in connection with government plants; reemployment and labor relations; market analysis and research; patents and licensing; and export markets," Mr. Cosgrove said.

RMA COMMITTEE MEMBERS planning post-war activities include: W. R. G. Baker, G-E vice-pres.; M. F. Balcom, Sylvania vice-pres.; John Ballantyne, Philco pres.; H. C. Bonfig, RCA Victor vice-pres.; Walter Evans, Westinghouse vice-pres.; A. H. Gardner, pres., Colonial Radio Corp.; Leslie F. Muter, pres., The Muter Co.; J. J. Nance, Zenith vice-pres.; E. A. Nicholas, Farnsworth pres.; Ross D. Siragusa, pres., Continental Radio & Tel. Corp.; Ray F. Sparrow, P. R. Mallory vice pres.; and A. S. Wells, Wells-Gardner pres.

SOLAR MFG. CORP. announces removal of general offices from the Bayonne, N. J. plant to 285 Madison Ave., New York 17, N. Y.

HAYDU BROS., maker of electronic products, has purchased a plant in Plainfield, N. J.

MOTOROLA has supplied some 40,000 radio dealers with a mailing piece that points out the necessity for straight thinking now to protect the post-war market.

WESTERN ELECTRIC has established a new plant in Haverhill, Mass. for manufacture of communications equipment.

WEBSTER PRODUCTS, 3825 W. Armitage Ave., Chicago, should be added to listing in the June Directory of ELECTRONICS as a manufacturer of the following products: dynamotors, generators, inverters, small motors, voltage regulators and special instruments.

HAYDU BROS

Burner equipment

PERFECT FORM—both in manufacture and performance, is more essential now than ever, if you are driven by war time speed, and the constantly growing need for greater production.

The traditionally dependable performance of Haydu Bros. Burner equipment, has been an assurance of uninterrupted economical production.

Today, thousands of Haydu Bros. Burners, in many styles and sizes, for Gas, Air and Oxygen, are used in plants of the general glass working industry from coast to coast, helping to speed those essential orders.

Specially designed Burners, Torches, Cross-fires and Mixers to meet your requirements.

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FOR BUYERS OF ELECTRONIC and RADIO SUPPLIES

SLOW service . . . that endless *waiting* for supplies to carry on rush electronic war work, has taken a knock-out blow from W-J EMERGENCY SERVICE! Now, with necessary priorities, you can write or phone our long experienced technicians for information or service . . . ask for one or one hundred (or more) different items with every assurance of getting them faster than you ever thought possible under present war conditions. Special departments, technical staffs, merchandise and methods have been streamlined to aid the war effort . . . to function with a degree of speed and efficiency heretofore unapproached in the history of radio and electronics supplies distribution. Make us headquarters for *all* your electronic needs. Write or phone today for REAL cooperation.

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A big Reference Book & Buyer's Guide crammed with helpful information on thousands of Radio and Electronic parts and equipment. Free to Purchasing Agents and other officials responsible for buying and specifying in industries using this equipment. Ask for it NOW on company stationery, please.

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Personnel

Dr. A. H. Rosenthal, physicist and electronic engineer, has been appointed director of research and development of Scophony Corp. of America, manufacturers of television projectors. He will head a group of scientists and engineers engaged in research of fundamental inventions in television and electronics.

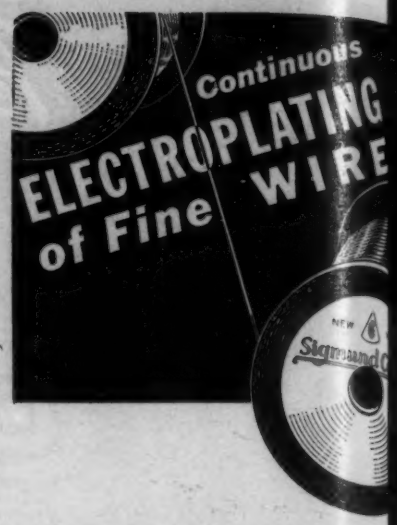
Richards W. Cotton, managing director of the British Rola Co. of London, and an American citizen, has been appointed assistant director at the British Air Commission in Washington, in charge of procurement of radio parts and equipment.

James O. Weldon, chief radio engineer of the Bureau of Communications Facilities of the OWI Overseas Branch, has been named chief of the Bureau to succeed Murry Brophy, who recently resigned because of ill health.

Nelson Blount, retired research worker and inventor for Bell Telephone Labs., died recently at the age of 64 in Morris Plains, N. J. He aided in the development of the throat microphone widely used by the armed forces, and the French type handset. He is reputed to have once ridden a torpedo to observe at first hand its reactions.

William D. Terrell, Chief of the FCC Field Division, retired recently at the age of 72. He began his career in government radio in 1911 as wireless ship inspector in the Department of Commerce, serving as chief of the Radio Division from 1915 to 1932 when he became chief of Field Operations of the Federal Radio Commission. He continued in this post, when that body was superseded by the present FCC, for a total of 40 years in government service, and was twice exempted from automatic retirement by executive order of the President.

George S. Turner becomes the new Chief of the Field Division of the FCC's engineering Department. He joined the Commission in 1931, and has been Assistant Chief of the Field Division since 1940.



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PAPER DIELECTRIC CAPACITORS—Wax or oil-impregnated sections in potted or oil-filled containers, A.C. and D.C.

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RADIO NOISE-SUPPRESSION FILTERS

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QUALITY COMPONENTS • EXPERTLY ENGINEERED • COMPETENTLY PRODUCED

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Making Parts Without Dies

No delay waiting for dies—parts ready quicker—deliveries speeded up—all to bring the Victory sooner! Women are rapidly taking a major place on the industrial front. DI-ACRO Precision Machines—Shears, Brakes, Benders—are ideally suited for use by women in making duplicated parts accurate to .001" — DIE-LESS DUPLICATING. Thousands of DI-ACRO Machines are now in use in War plants.

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Di-Acro Brake forms non-stock angles, channels or "Vees". Right or left hand operation. Folding width — Brake No. 1 — 6". Brake No. 2 — 12". Brake No. 3 — 18".

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Di-Acro Bender bends angle, channel, rod, tubing, wire, moulding, strip stock, etc. Capacity — Bender No. 1 — 1/4" round cold rolled steel bar. Bender No. 2 — 1/2" cold rolled steel bar.

SHEARS
Di-Acro Shear squares and sizes material, cuts strips, makes slits or notches, trims duplicated stampings. Shearing width — Shear No. 1 — 6". Shear No. 2 — 9". Shear No. 3 — 12".

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It's an eye-opener on what you can do without dies, shows typical parts, and gives sizes and capacities of all models of Di-Acro Shears, Brakes, Benders.

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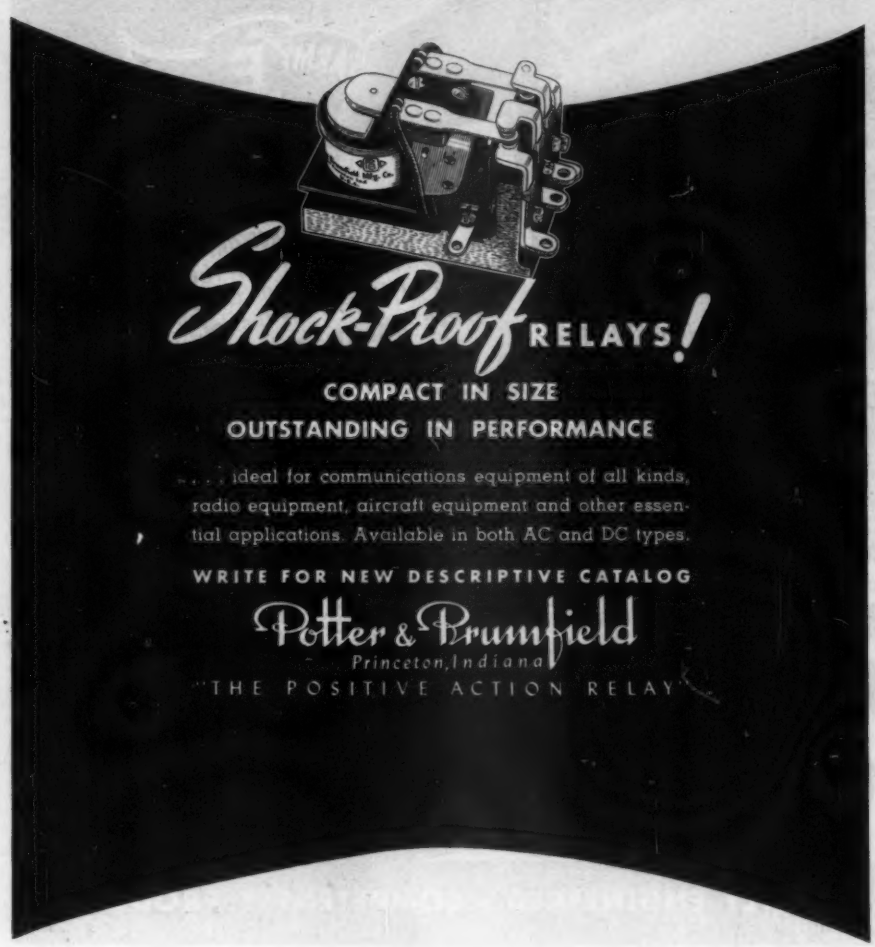
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COMPACT IN SIZE
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. . . . ideal for communications equipment of all kinds, radio equipment, aircraft equipment and other essential applications. Available in both AC and DC types.
WRITE FOR NEW DESCRIPTIVE CATALOG
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Princeton, Indiana
"THE POSITIVE ACTION RELAY"

David Grimes, vice president in charge of engineering for Philco Corp., was killed early in September when the transport plane in which he was traveling crashed into a mountain in Northern Ireland. He was abroad on a special war mission and was in the company of Commodore James A. Logan, Commandant of the United States Naval operating base at Londonderry, who was also killed in the crash.

During the World War Grimes saw military service as chief radio officer at Kelly Field, Texas, and in the last months of the war as signal officer attached to the British Air Force in England. After returning to this country, he spent a few years as research engineer in telephony for AT&T, and then established his own organization to do consulting

David Grimes

research engineering for several companies. From 1930 to 1934 he was license engineer for RCA.

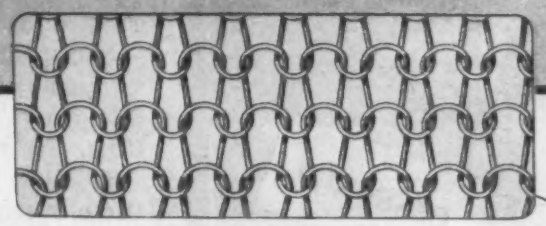
He joined Philco in 1934 as engineer in charge of research and engineering for home radio sets, and was named chief engineer in 1939. Since 1942 he has been vice president in charge of engineering.

It was Grimes' belief that a network of relay television relay stations to beam programs from one station to another would make it possible to develop a nation-wide television service. Under his direction Philco put a successful television relay system into operation between New York and Philadelphia in 1941.

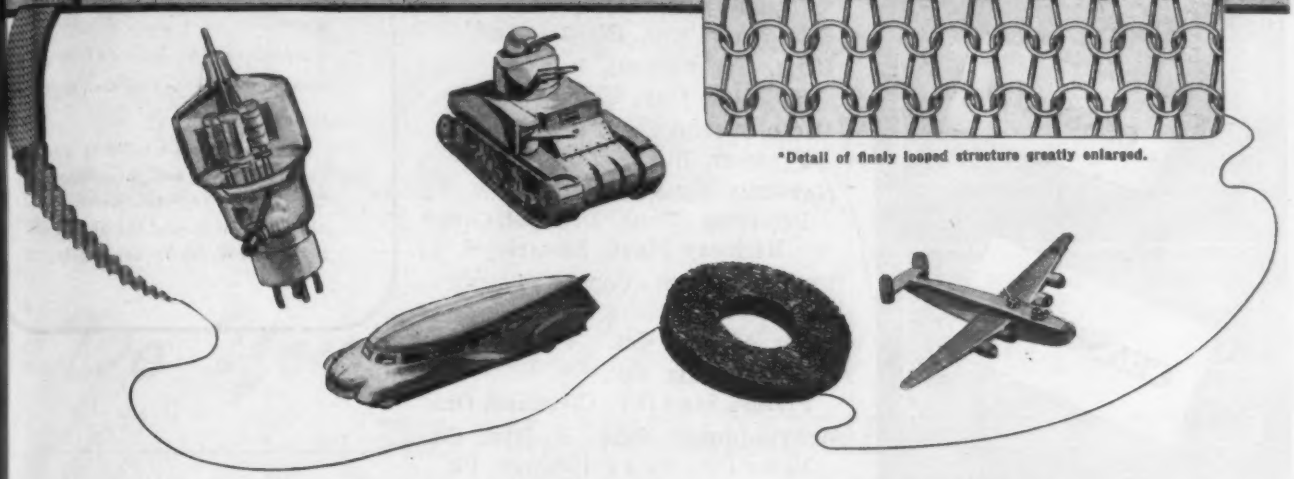
Robert Bartley, vice-president of the Yankee Network, has been appointed War Director of the National Association of Broadcasters.

METEX METAL MESHES

A new material—Knitted not woven—having unique characteristics and features adaptable to application for which other materials are unsatisfactory.



*Detail of finely looped structure greatly enlarged.



Features and Characteristics of METEX METAL MESHES

Metex knitted wire mesh is a new material with a number of interesting possibilities in electronic applications. It is not woven, but is made in continuous tubular form from a single wire.

A large range of choice is available as to the percentage of free area in a given fabric. Both flat or round wires can be used. Sagging and buckling from a rising temperature are avoided, because the increase in length of the wire is taken up by the curvature in the loops.

The material can be manipulated into foraminous structures with a controlled percentage of free volume. Similar structures can be designed for resiliency at temperatures above the range of organic materials. Relatively large openings in ratio to the wire diameter are possible where required, thereby increasing the percentage of free area beyond the amount possible with woven screening.

We are familiar with techniques for knitting fine mesh screens from tantalum, tungsten, molybdenum, nickel, and heat resisting alloys. Illustrative samples are available upon request.

Cooperation of our Engineering Staff is offered for research and development projects.

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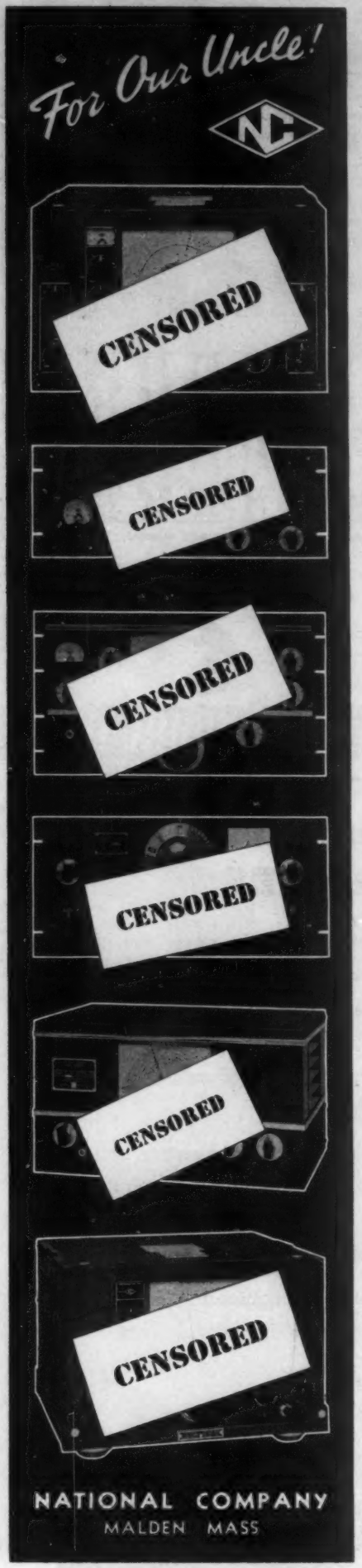
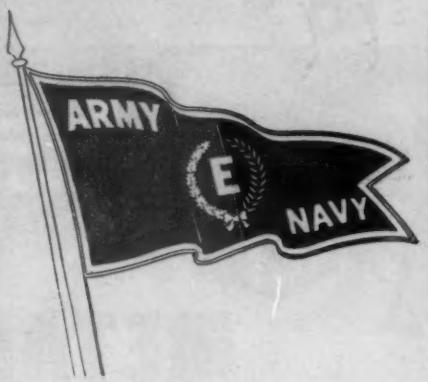
METEX Products





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A total of 1910 plants and projects have been granted the Army-Navy "E" for excellence in production of war materials. This is the first time since the joint award was inaugurated a year ago that the total number of awards has been made public. No official compilation has been made of the total number of plants in this country, both prime and subcontractors, but on the basis of several statistical reports, it is estimated that less than 2½ percent of the eligible plants have received the award to date. Stringent eligibility requirements account for the relatively small number of plants receiving the honor in comparison with the great number working on war contracts. Of the 1910 plants which have received the "E", 1188 were nominated by the Army and 722 by the Navy.

—◇—

OVER four-fifths of the 1,833,000 workers added to the payrolls of American factories between April 1942 and June 1943 have been women.

WANTED:
RADIO ENGINEER

Permanent radio engineering positions in Southern California for men with creative and design aptitude, especially with UHF circuits. Starting salary and advancement depends upon the engineer's experience and ability.

Applications are solicited from persons that are not using their highest skills in war work.

Write complete qualifying educational training and experience to Chief Radio Engineer, Bendix Aviation, Ltd., in care of The Shaw Company, 816 W. 5th St., Los Angeles 13

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Shows description, gives dimensions and output of small motors from 1/3000 h.p. to 1/3 h.p. plain and back-geared motors for A.C., D.C., or Universal operation—dependable, efficient and economical SpeedWay Motors embodying the "know how" developed through more than 30 years of specialization in small motors — the "know how" that has answered so many war problems, for all branches of the service.
If you use small motors, write for this new catalog today. If you have small motor problems, send in your specifications for SpeedWay's recommendation.
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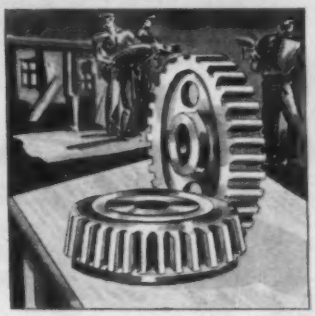
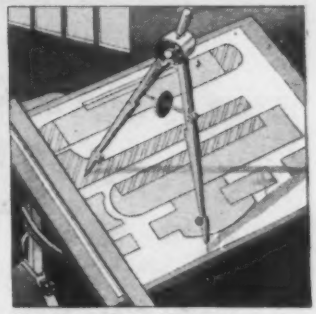


Cloth Combines With Plastics To Displace Metals In Gears, Gaskets and Washers.



Cloth Protects Original Designs; Assures Lasting Blueprints.

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THE AMAZING ADAPTABILITY OF CLOTH?

Immediate demands are that weight, time and costs be reduced, products improved, and new products conceived. Cloth is helping to achieve all these objectives.

Think what inflatable boats and rafts of coated cloth, to serve where wooden boats and metal rafts are impossible, mean in saved lives and lessened suffering. Think what is being achieved with cloth and plastic in lamination, with cloth in adhesion.

An accompanying illustration may suggest how something you may have conceived, could be made a reality. The adaptabilities of impregnated, coated and filled cloths seem limitless.

Whatever your conceptions or problems, let us know. Something we already have done, will probably suggest a solution to us, just as these illustrations of some processings may suggest new possibilities to you.

CURRENT HOLLISTON PRODUCTION includes COATED AND IMPREGNATED FABRICS, mildew proof — fire, weather and water resistant — gas impermeable, etc. INSULATING CLOTH BASE — SEPARATOR CLOTHS, rubber, starch-filled, glazed. TRACING AND BLUE PRINT CLOTHS white and blue, ink or pencil. MAP CLOTH. PHOTO CLOTH, self-adhesive. REINFORCING FABRICS. SIGN, LABEL AND TAG CLOTHS, waterproof to take any ink, meet any inking problem. BOOKBINDING CLOTHS. SHADE CLOTH, impregnated waterproof, opaque, translucent or light proof.

IN DEVELOPMENT: Mildew-proofing and asphalt-impregnating processes; fire and weather-resistant treatments; synthetic resin fillings and coatings applicable from nettings to duck. In general, Holliston can convert any print cloth, sheeting, twill and duck in widths from 30" to 80" and can dye, impregnate, coat and fill in any color to specified stiffness or pliability, hand, bond, weight addition and tensile strength, including Elmendorf tear strength, for any trade, commercial or industrial use. We have both the wish and the capacity to cooperate on production problems. We urge you to consider CLOTH, and invite you to consult with us concerning possibilities and developments for your specific requirements.

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PERMANENT MAGNETS

The Arnold Engineering Company is thoroughly experienced in the production of all ALNICO types of permanent magnets including ALNICO V. All magnets are completely manufactured in our own plant under close metallurgical, mechanical and magnetic control.

Engineering assistance by consultation or correspondence is freely offered.

THE ARNOLD ENGINEERING COMPANY
147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Speech Scrambling

(*Continued from page* 111)

from the 6C5 oscillator. A fixed value is shown for R_{14}, but it might be well to use a standard volume control instead to provide for relative adjustment of the amplitudes of the inverting frequency and incoming speech frequencies.

The frequency from the 6C5 oscillator is controlled by means of a variable resistance and capacitor in series. The control is the large dial shown on the front of the panel. The values of the various components comprising the oscillator circuit have been chosen so that a frequency of 3000 cycles is provided with the control near the center position. A Wien bridge or any other well-known type of oscillator may be used for supplying the inverting frequency.

Because of the close proximity of the component parts of the inverter, hum pickup is reduced by isolating power transformer T_1. This transformer is mounted externally in a small can and made a part of the line cord.

In operation, the inverter may be used for both scrambling and unscrambling. If desired, two units may be placed at either end of a two-way circuit with the usual balanced hybrid coils, to provide a complete privacy system for two-way telephone communication.

Band Splitting

To secure privacy of speech by means of band splitting, the speech-frequency band is divided as to frequency into a plurality of sub-bands, some of which may be transmitted without modification. Others first have their frequency order inverted and are then transmitted along with the unchanged sub-bands, or, if desired, each of the sub-bands may be inverted before transmission.

It is preferable in this type of secrecy system that the frequency width of each of the sub-bands be kept narrow enough so as to be incapable of reproducing understandable speech by itself. The maximum width of a sub-band must not exceed certain limits because of the large amount of intelligibility that would be contained in a band only several

ULTRA-SENSITIVE MULTITESTER

20,000 OHMS PER VOLT

The R.C.P. Model 461P Ultra Sensitive Multitester provides a wide range of measurements and features required for general laboratory purposes. It is also ideally suited for field and shop measurements on military, and naval equipment.

Sensitivity of 20,000 ohms per volt on all D.C. measurements results in negligible loading of delicate circuits. Wide scale, 4½" rectangular meter used, with a movement of 50 microamperes. Readings as low as 1 microampere can be made on the 100 microampere scale.

A.C. voltmeter sensitivity is 1,000 ohms per volt. Meter movement is 2% accurate. Shunts and matched pair metallized voltage multipliers accurate to within 1%. A suppressor type copper oxide rectifier is used.

RANGES:	
D.C. voltmeter:	0-2.5-10-50-250-1,000-5,000 volts.
A.C. voltmeter:	0-2.5-10-50-250-1,000-5,000 volts.
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D.C. microammeter:	0-100 microamps.
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hundred cycles wide, especially if this portion were chopped out of the spectrum in the neighborhood of 1000 cycles.

The number of sub-bands into which the voice frequency band is divided is dependent on the degree of privacy required. The greater the number of sub-bands, the greater the number of transposition combinations that are possible.

The combination of transposition and inversion of the various sub-bands is accomplished by suitable modulation processes. By using bilateral modulators, the same apparatus may be used for retransposing and reinverting the sub-bands of a speech band that has been rendered unintelligible in the manner described.

Band-Splitting Circuit

Figure 3 represents schematically a band-splitting privacy system. The normal speech currents are derived from the line L_1 and impressed on the sub-band filters F_1, F_2, F_3, and F_4. These filters serve to divide the speech currents into four equal sub-bands which may each have a width of b cycles. For instance, filter F_1 will pass a range of frequencies f to $f + b$, where f is representative of the lowest essential voice frequency necessary for transmission.

Each input filter is connected to supply selected voice currents to four separate modulators M_1, M_2, M_3, and M_4. These are bilateral modulators of the double balanced copper-oxide type, shown in detail in the case of M_4. Each modulator is essentially a lattice network having a copper-oxide rectifier unit in each of the series and lattice arms, and two transformers each having two windings, one winding of each transformer being connected across one of the two sets of termials of the network, and the source of carrier current for modulation with the voice frequencies supplied to the other windings of each transformer being connected across the midpoints of the first two windings. However, any of the other known types of bilateral modulators may be used, such as the balanced modulator shown in Fig. 38, p. 550 of Radio Engineering Handbook*.

The carrier frequencies supplied

* Edited by K. Henney. *McGraw-Hill Book Co., New York 18, N. Y.*

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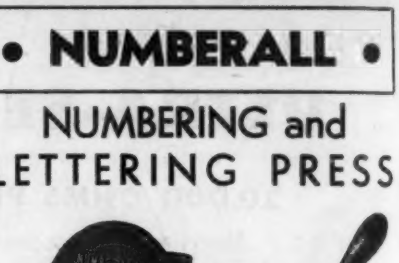

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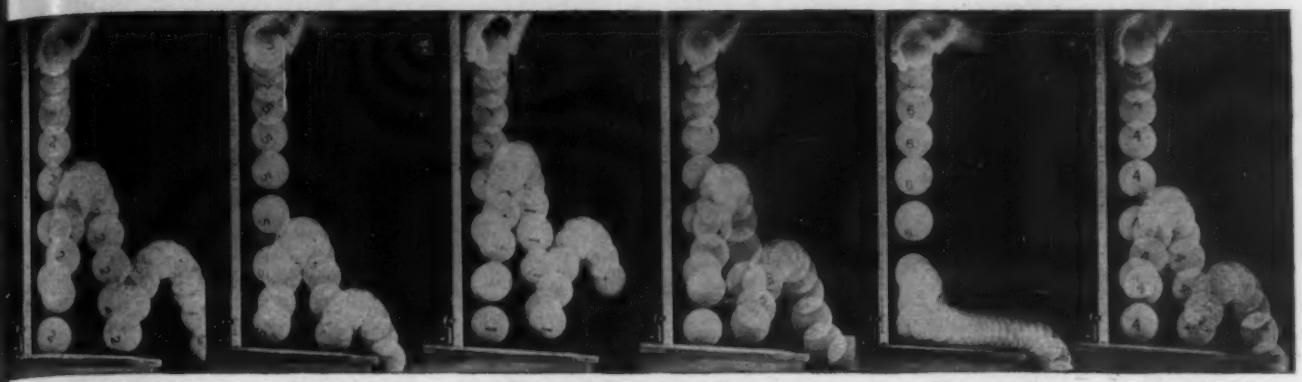

2 (Synthetic) 5 (Synthetic) 1 (Natural) 3 (Synthetic) 6 (Synthetic) 4 (Synthetic)

SIX SOLID BALLS OF RUBBER caught in the act of bouncing by a high-speed camera that shoots at the speed of 1/6592 of a second. All of them were dropped from exactly the same height...and yet, what a difference there is! One of the balls is made of a compound containing natural rubber. Each of the other five balls contains one of the five major types of synthetic rubber.

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It is a whole family of new materials each with its own important uses

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3. Used for making solvent and lacquer hose and other products where the utmost resistance to solvents is needed...better than natural rubber for these purposes.

4. Used for making bullet-sealing fuel hose for planes and for other uses where high resistance to aromatic fuels is essential.

5. Used for coating barrage balloons, tank linings, packings, acid hose, wires and cables. This type does not support combustion and is highly resistant to sunlight and chemicals.

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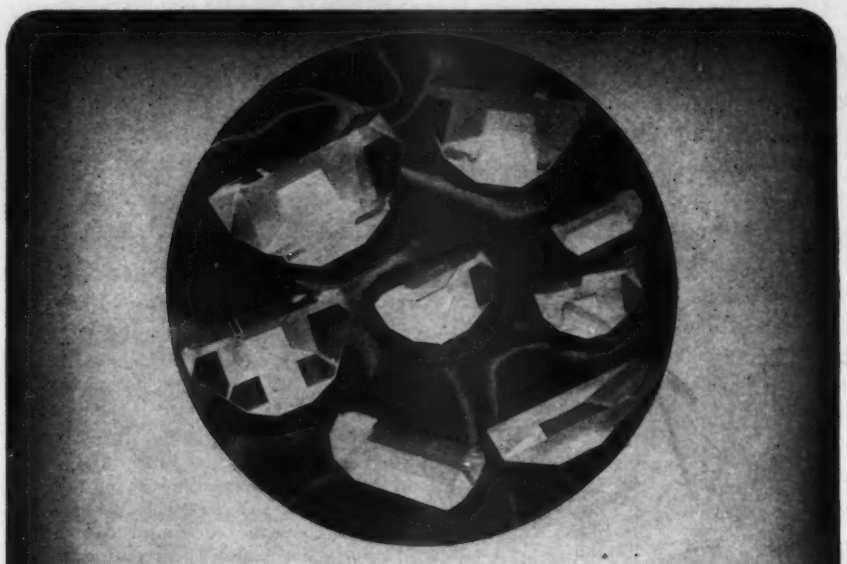

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to these modulators are so chosen that the sub-bands may be transposed with respect to each other in various combinations.

The outputs of each of the four modulators may be variously connected to the output band filters F_1, F_2, F_3, and F_4, as shown in Fig. 8. These output band filters have exactly the same cut-off limits as indicated for the input band filters.

By shifting the connections of the modulators to output filters and employing various carrier frequencies, we alter our different combinations of transposition and inversion of sub-bands.

Transposition in Band Splitting

Transposition of sub-bands with and without frequency inversion is shown in the schematic by the solid-line connections between modulators and output filters. The necessary carriers are provided when the modulator switches are in position 1.

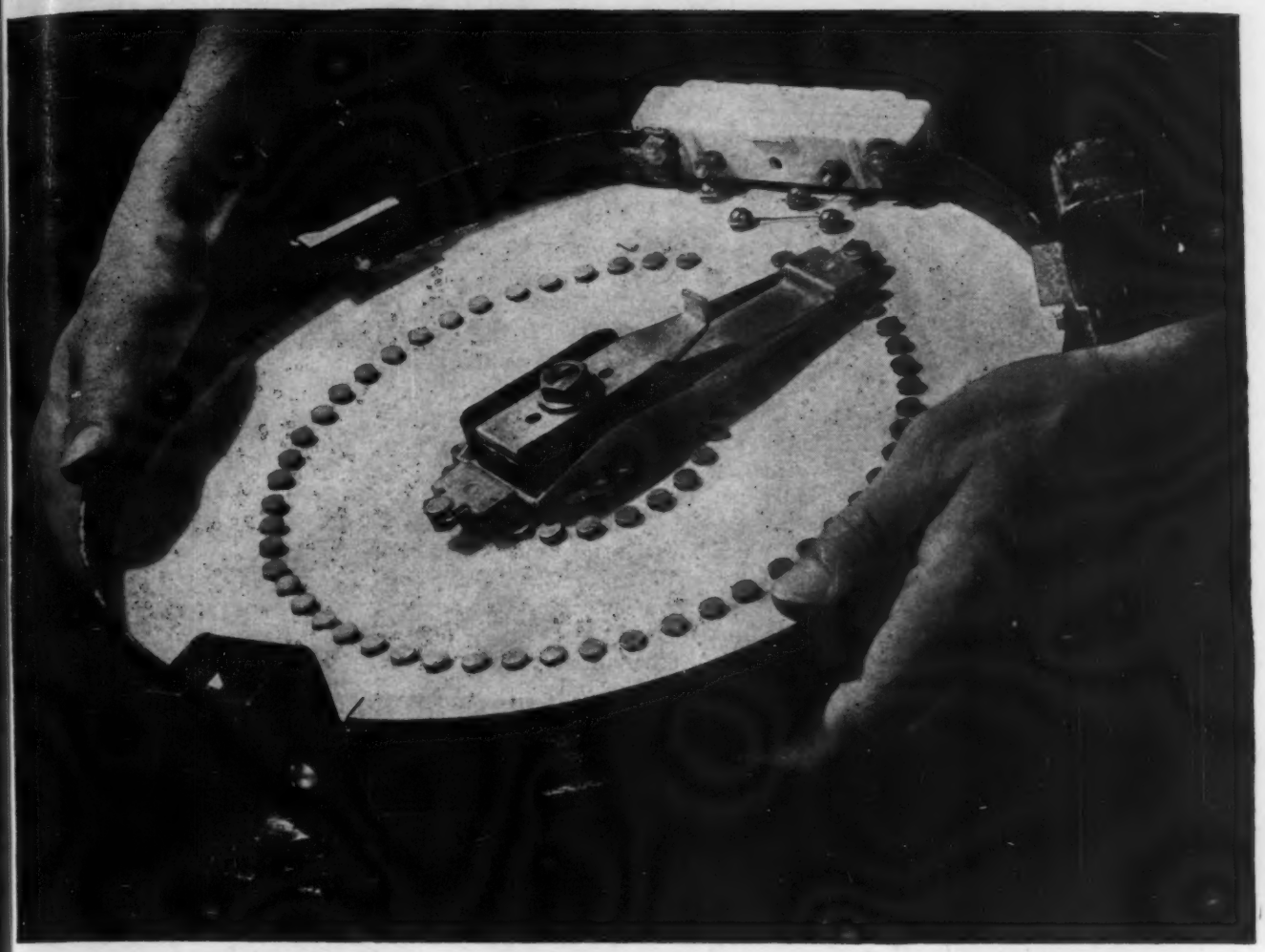
In the case of the dotted-line connections and the carrier switches in position 2, each of the sub-bands is inverted as well as displaced.

With reference to the solid-line connections and the carrier switches in position 1, if a carrier current c is supplied to M_1, with input frequencies of f to $f+b$, there will be produced a lower and upper side-band, namely $c-f$ to $c-(f+b)$ and $c+f$ to $c+f+b$. The range of frequencies $c+f$ to $c+f+b$ is the original band f to $f+b$ raised up in the spectrum by the value of c, and corresponds to the sub-band of the original voice band extending from $f+b$ to $f+2b$. This range of frequencies can then be selected by filter F_4 and transmitted to the output circuit L_2. The action of modulators M_3 and M_4 in this case would be similar to that of M_1.

The original voice sub-band $f+3b$ to $f+4b$ from filter F_4 is displaced down in the spectrum to a position occupied by the original voice sub-band f to $f+b$. Here, in addition to being displaced, the frequency orders of the speech components are inverted, as will be seen by the following action.

With input frequencies of $f+3b$ to $f+4b$ and a carrier of $c+3b$ applied to the modulator M_4, there will appear in the output the side-bands $c+3b+f+3b$ to $c+3b+f+4b$ and $c+3b-(f+3b)$ to $c+3b-(f+4b)$.

It will be seen that the lower side-



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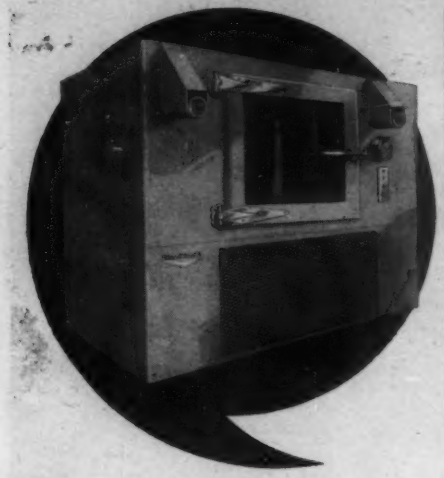

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band, $c+3b-(f+3b)$ to $c+3b-(f+4b)$, is an inversion of the original input frequencies $f+3b$ to $f+4b$ which now occupy the position of the original voice sub-band f to $f+b$.

It will be noted in the arrangement of this apparatus that by shifting the connections of the filters and carriers in various combinations from time to time in such a manner that corresponding combinations are simultaneously employed at the two terminals of a receiving circuit at the same time, it will be extremely difficult for an unauthorized listener to obtain an intelligible message.

Shifting from one combination or scheme of interrelation to another can be accomplished by switching relays under control of timing cams associated with an accurately controlled driving means to provide additional secrecy.

The use of bilateral modulators allows the transmitted and received waves to pass in opposite directions through the same privacy apparatus, to produce a scrambled message for transmission or to unscramble a message from a received secret wave.

Attenuation with Band Splitting

Another type of privacy system proposed is an arrangement whereby the speech band is divided into a plurality of sub-bands, as by filters F_1 to F_4 of Fig. 3. Each sub-band is then subjected to different degrees of attenuation before transmission instead of being displaced by modulation. Accordingly, when the voice is transmitted it will be so distorted as to be practically unintelligible. To restore the voice to normal at the receiving station, the sub-bands of the voice are again subjected to unequal degrees of attenuation, so that all of the sub-bands will be attenuated to the same degree and the distortion removed.

Phase Shift with Band Splitting

Still another arrangement for secret telephony is to alter the order of occurrence of the various frequency components of speech. Briefly, this is accomplished by taking the subdivided waves, as from filters F_1 to F_4 of Fig. 3, and producing a phase or time shift in some of the sub-bands with respect to others before transmission. This phase shift is produced by the use of a storage device such as the telegraphone. The

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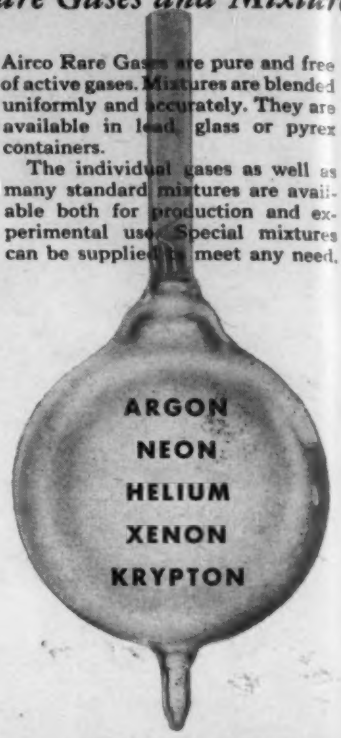

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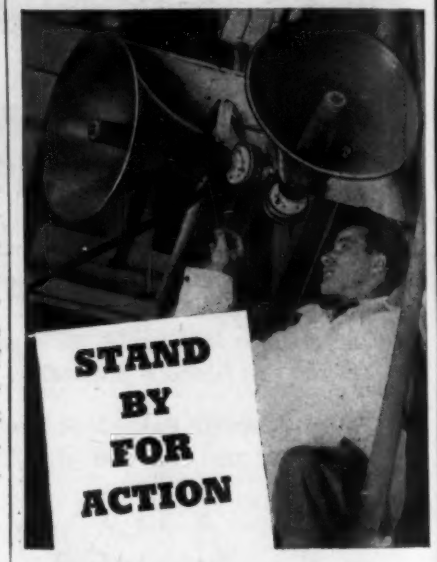

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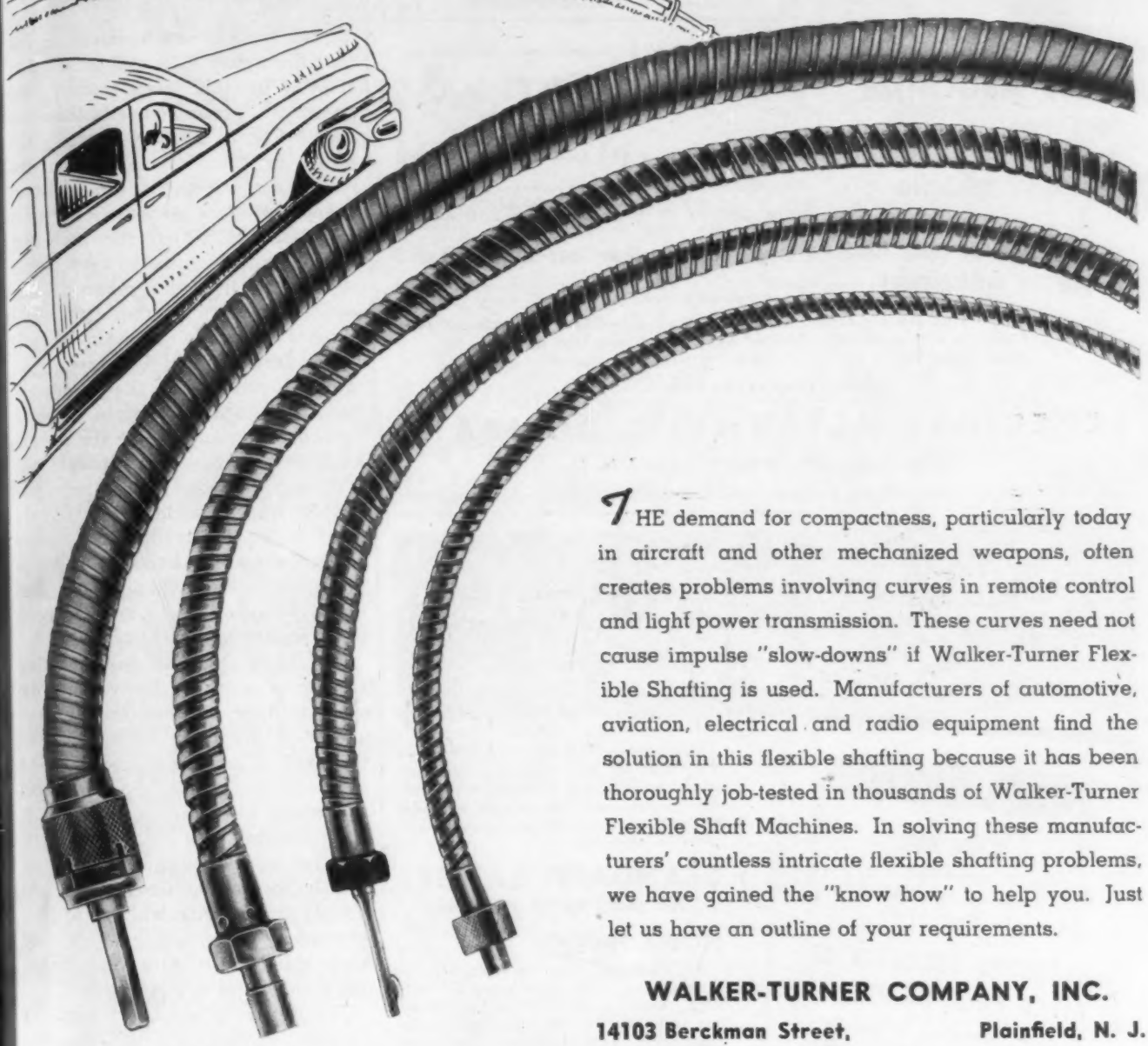

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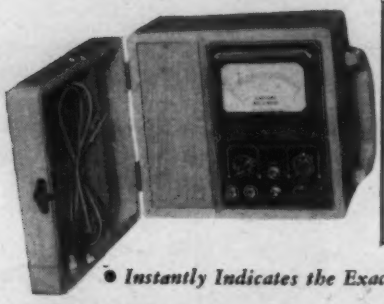

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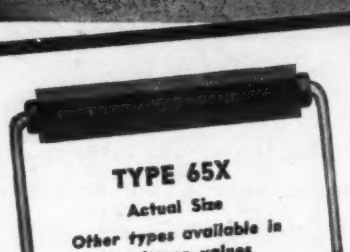

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various sub-bands are then recombined and transmitted, or they may first be shifted to a different frequency level and then transmitted. At the receiving end employing this system, the various sub-bands are again separated by filters, and such a phase shift is made in the individual sub-bands as is necessary to reproduce the normal speech waves.

Variable Inverting Frequency

Still another arrangement is one that the writer built and patented in 1939*. In this arrangement, the speech was scrambled as in the process of Fig. 3. Then, to destroy the limits or boundaries between the plurality of sub-bands, the combined frequency bands were inverted by a modulator in which the inverting frequency was caused to vary cyclically in an irregular manner. The varying inverting frequency, combined with a complex scheme of variation, provided a high degree of secrecy. It can be seen that in accordance with such a principle, it would be practically impossible for an unauthorized listener to separate the individual sub-bands as their frequency limits would never remain fixed in the spectrum. To separate the individual sub-bands it would be necessary to know the inverting frequency at any instant and the complex manner in which it varied.

Let us assume that the inverting frequency varies cyclically in any desired manner between the limits c and $c+d$, where d varies between zero and a predetermined limiting value. If the speech frequency band as a whole, such as from L_2 of Fig. 3, is represented by s and if the inverting frequency is modulated by these speech frequency currents, the resulting components will be of frequencies $c+d-s$ and $c+d+s$. The lower side-band $c+d-s$ would be the one selected for transmission.

The receiving station cooperating with such a system would use substantially the identical means used for transmitting but in reverse.

* U. S. patent No. 2,301,455.

—◇—

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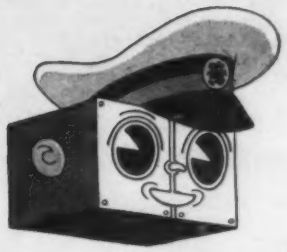


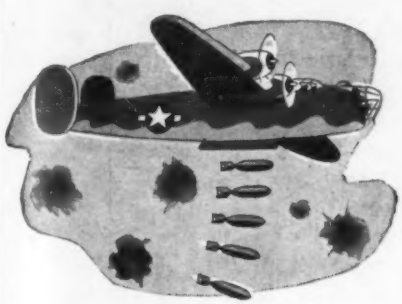
Song of Elmer... the pilot who never gets tired

He holds no place in the Officer's Mess
for he does not sleep or eat,
He's the Quietest Birdman ever took
his place in a cockpit seat—
He joins no laughter, nor shoots the breeze,
nor whistles, nor hums, nor sings,
But he's flown more planes than any man
who ever wore pilot's wings...

...has Elmer!

He's an old, old hand, as old hands go
in a young man's game today,
For he circled the globe in 'Thirty-three
with Post in the Winnie Mae—
He's an Army man, he's a Navy man,
and he flies with the R.A.F.,
And the Yankees say, and the British say
of pilots, he's the best...

...is Elmer!



Often when bombers have levelled off
for the last tense bombing runs,
And the bomb-bay doors are opened wide,
and the gunners man the guns,
When the flak comes up as the bombs
go down, and the target zone is clear,
Then who is the pilot who holds the course
set by the bombardier...?

It's Elmer!

He can hold a plane on a chosen course
while the crewmen rest or sleep,
He can level off for a landing glide,
or bank her sharp and steep—
He can spiral up, he can spiral down,
or hold her level and true—
His hydraulic muscles never tire
the way human muscles do...

...not Elmer's!

And so bombing, transport, and cargo
planes, take Elmer on every flight
To spare the pilot and rest the crew
for emergency, storm, or fight—
He needs no rest, for he never gets tired,
being only a cold machine,
Just wheels and wires and gears and cogs,
with brackets and stuff between...

...is Elmer!

He wears no medals, he holds no rank.
Why should he? He cannot feel
The courage that flares in time of need
for he's only alloy and steel!
So when *nerve* is needed, the bombardier,
the pilots, the gunners, too,
The navigator, and all the rest,
are the boys who pull her through...

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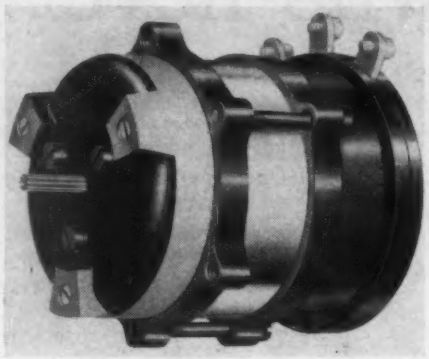
Three types (776-01, 776-02 and 776-04) of drag cup motors are available. Their characteristics are shown in the following table.

Characteristics	776-01†	776-02	776-04
Frequency	400 cycles	60 cycles	400 cycles
Voltage			
Phase 1*	24 volts	100 volts	125 volts
Phase 2	35 volts	100 volts	110 volts
Number of Poles	6	2	6
Average Impedance*			
Phase 1—Ohms	48 Ohms	1470 Ohms	1250 Ohms
Phase 2	145 Ohms	1590 Ohms	1620 Ohms
Current—Amperes*			
Phase 1	0.50 amps	0.068 amps	0.100 amps
Phase 2	0.24 amps	0.063 amps	0.068 amps
Speed—no load	5700 RPM	3000 RPM	5500 RPM
Torque—stalled	0.70 in/oz.	0.50 in/oz.	0.50 in/oz.
Stopping time	1.35 sec.	0.2 sec.	0.6 sec.
Reversing Time	0.3 sec.	0.12 sec.	0.15 sec.
Temperature Rise	50° C	43° C	40° C
Weight of Motor	12.0 ounces	12.5 ounces	12.0 ounces
Weight of Rotor	0.53 ounces	0.42 ounces	0.42 ounces
Length—over-all	2.750 in.	2.750 in.	2.750 in.
Diam.—max. outside	2.750 in.	2.750 in.	2.750 in.

* Running—no load.
† 776-01 Signal Corps No. Mo-27.



A catalog called "Remote Indicators and Motors with Electronic Applications" contains a page of outline drawings of basic Type 776 drag cup motors. Also in the catalog are detailed descriptions and electrical characteristics of Type 787 rotatable transformers, which were briefly described in this column in August ELECTRONICS. Other units described in the catalog are two-phase generators, micro-horsepower Telegon units, and Teletorque units.

Write to Electrical Development Dept., Kollsman Instrument Division of Square D Co., 80–08 45th Ave., Elmhurst, N. Y.

Automatic Control Aid

"FLASHTRON" DESIGNATES an electronic package unit which serves as a sort of nerve center in automatic control setups and makes it practicable to closely approach zero tolerance in regulating variables occurring in industrial processes such as pressure, temperature, liquid level, flow, speed, motion, voltage, air, fuel relation, specific gravity, gas analysis, etc. It is a buffer control element operating between the primary sensitive element and the power operating control element.

The unit requires negligible power for actuation, and may be operated from super-sensitive primary actuating elements of various types. It furnishes the power necessary for actuation of power operating elements, slower-acting primary control elements. Output circuits accommodate the alternate energizing of loads within the range of the instrument (blower fans, valve control, heating elements, etc.) which may be connected to it.

Advantages claimed for the unit are its high-speed operation and its immediate response to sensitive actuation. One of the two output circuits is always energized but both cannot be energized simultaneously with contactor-type actuating devices. The dual circuit output energizing system is especially suitable for the control of proportioning or positioning control elements such as valves operating from reversible motor drives. Since one or the other circuit must be in operation at any given instant, the valve will be constantly reset to the desired position in exact response to the performance of the primary sensitive element which is actuating the Flashtron unit.

While the Flashtron cannot compensate or correct for lag in any of the other control elements in the system in which it is used, the manufacturer states it does not in any way limit the full utilization of the performance of any of these other elements. The unit is lightweight, measures $11\frac{1}{2}$x$7\frac{1}{2}$x$3\frac{5}{8}$ inches, and comes housed in an all-steel box with provision for connecting it to a 115-volt, 60 cps a-c line, the actuating circuit and two control sections.

Thordarson Electric Mfg. Co., 500 West Huron St., Chicago, Ill.

Direct-Reading Frequency Meter

ILLUSTRATED IS A frequency meter which retains an accuray of 2 percent over the entire range of 50,000 cycles. It will drive a recorder without the use of auxiliary amplifiers. An overload cutout protects the recorder from damage. The instrument is also suitable for use as a laboratory test instrument, for testing quartz crystals, for use in a wow meter for phonograph motors, and for experimental work as the base of a frequency modulation indicator. When combined with a phototube, a

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Dielectric Strength Dry VPM	280	1000	1200	900
Dielectric Strength Wet VPM	450	910	900	800
Low Temperature Flexibility °F. (°C.)	−85 (−65)	−63.4 (−53)	−59.8 (−51)	−22 (−30)
Low Temperature Impact °F. (°C.)	−70.6 (−51)	−54.4 (−48)	−41 (−40.56)	−5.8 (−21)
Elevated Temperature Continuous °F. (°C.)	150 (65.56)	188.6 (87)	194 (90)	190 (87.78)
*Soldering	Flows	Flows	Flows	Good
**Aging (Baking) at 100°C. (212°F.) good after	100 days	100 days	130 days	50 days
Tensile Strength PSI	2550	3000	3200	2900
Hardness Shore "A"	40-45	55-60	65-70	75-80
Flame Resistance	Do not support combustion			
Water Absorption %	−1.4	+0.4	+0.9	+0.75
Chemical Resistance	Good	Very Good	Very Good	Good

All tests made on Standard #8 Tubing.
*1 minute immersion in molten solder at 450°F.
**Rapid flattening between jaws of a vise to thickness of twice the wall.

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light source and amplifier, the instrument can be used as a speed indicator to read speeds difficult to determine, such as are encountered with ultra-speed centrifuges.

Maximum frequency is 50,000 cycles in ranges of 0-100; 0-500; 0-1000; 0-5000; 0-10,000; and 0-50,000. Each frequency range can be individually adjusted for maximum accuracy. The frequency is indicated directly on a front panel, or on a separate recorder. The meter has an in-

put impedance of 100,000 ohms or over. It will measure frequency regardless of input signal voltage variations between ½ and 200 volts. Stability is maintained with line voltage variations between 105 and 125 volts. The meter does not use d-c amplifiers. It is available for either relay rack or cabinet mounting.

Industrial Electronics Div., North American Philips Co., Inc., 419 Fourth Ave., New York, N. Y.

Insulation Breakdown Testing Instruments

ALL-PURPOSE INSULATION breakdown testing instruments known as "Hypot" are available in standard models (No. 406, 407, 408, 409, 410), as well as in special designs. The instruments are mounted on rubber tires and have handles at the back for easy portability. Features given for these instruments include ample capacity for all testing; easy control from zero to maximum voltage which is indicated on the scale of a large open-scale meter; full 500-ma capacity to meet AIEE specifications; a 1½ kva transformer on standard models, and a 3 kva transformer on models having a "burn" test; completely self-contained and arranged for convenience. Form No. A9-743-2M describes these testers in detail and is available from the manufacturer, Associated Research, Inc., 231 South Green St., Chicago 7, Ill.

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TYPE '26 HIGH-VOLTAGE capacitors a for use in x-ray, impulse genera and other intermittent d-c or conti ous a-c high-voltage applicati such as indoor carrier-coupler pacitors, test equipment and spe laboratory work. The capacitors oil-impregnated, oil-filled with Hy vegetable oil and are built with sulated and matched sections of u form capacitance, connected in seri Equal voltage stresses are ma tained for all sections with a unif voltage gradient throughout length of each capacitor. Alumin foil with a number of tab connect provides high conductivity with inductive reactance. Capacitor tions are dried and impregnated der high vacuum in a closely-c trolled long cycle) to eliminate vo and also provide for high insulati values and lower losses.

The case is of laminated bake

tubing, protected by a high-resi ance insulating varnish for high electric strength and maxim safety from external flashover. T manufacturer states the capacit will give dependable operation a long service life at rated voltag and ambient temperatures up to deg. C. The terminals are two-pi cast-aluminum end caps with ba lite-treated cork gaskets, which locked in to provide leak-proof he metic sealing. Caps are availa with mounting feet for space-savi assemblies in series, parallel series-parallel arrangements. A obtainable with plain end caps.

Aerovox Corp., New Bedfo Mass.

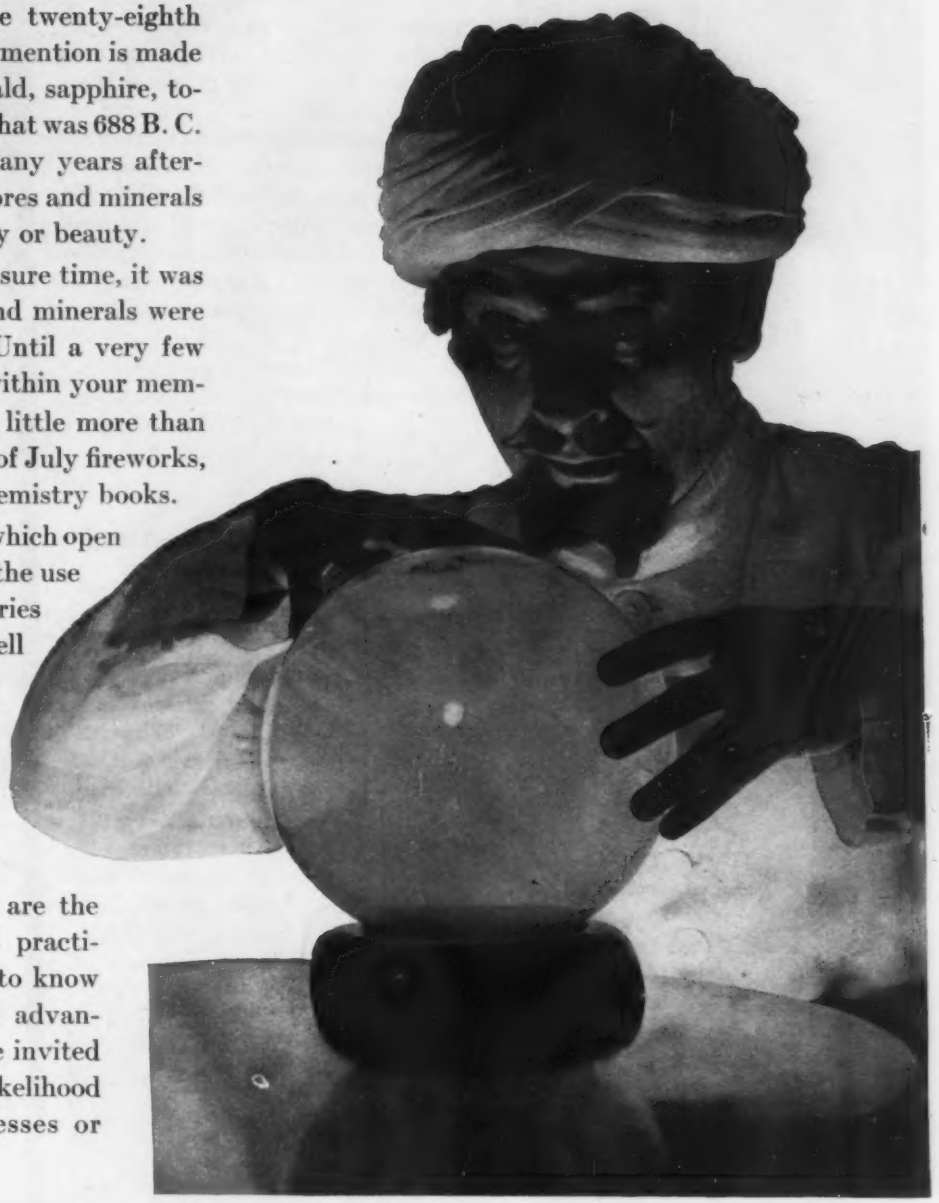
Wanted: More Crystal-Gazers

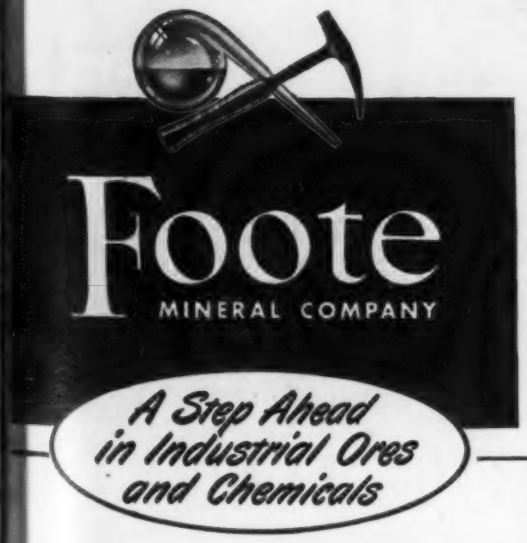
the thirteenth verse of the twenty-eighth apter of the Book of Ezekiel, mention is made diamond, beryl, onyx, emerald, sapphire, to-z and other precious stones. That was 688 B. C. r many years before and many years after-rd, the world's crystals and ores and minerals ere prized only for their rarity or beauty.

In fact, as mineralogists measure time, it was arcely yesterday that ores and minerals were scovered to be of real use. Until a very few ars ago, for example—well within your mem-y—abundant strontium was little more than red glow reserved for Fourth of July fireworks, thium an obscure name in chemistry books.

Today, there are discoveries which open eater and wider horizons for the use ores and minerals; discoveries hich affect your industry as well scores of others. Foote, by ason of long experience and tensive research into ores d minerals and chemicals, in the forefront of these velopments.

You who in your industry are the rystal-gazers" of the most practi-l kind, you whose job it is to know hat new thing can be used advan-geously in your products, are invited write us. There is good likelihood at Foote products, processes or search can benefit you.





ELECTRONICS NEED ZIRCONIUM

Melodies from your local station or messages from a bomber owe a bit of thanks to the evolution of zirconium. Zirconium, long known as an excellent "getter" for vacuum tubes, was difficult to separate from the bad companionship of other volatile metals which coated insulators and mirrored tubes, causing leakage and lowering the load limits of the tubes. Foote engineers turned the trick shortly after Pearl Harbor, perfecting a process for purifying Zirconium and then producing large quantities of sorely needed pure zirconium metal powder. Not long ago, Foote came through again with the timely development of ductile zirconium for forming tube elements and production is being rapidly expanded. These two products are war vital, their possibilities virtually unlimited. We urge you to write for information on either or both for radio or electronics applications.

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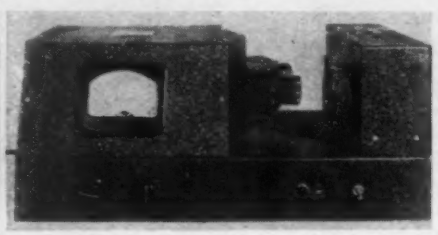
A bulletin containing technical data is available from Kurman Electric Co., Dept. A E, 30–30 Northern Blvd., Long Island City, N. Y.

Densitometer for Measuring Transparent Materials

DENSITOMETER SERIES D90, is a photoelectric system for accurate measurement and control of the density of transparent films, filters, plastics, gases and liquids. The system was developed originally for use in the manufacture of extremely dense optical filters to maintain accurate control of transparency during large quantity runs, but it may also be used for constant density control of films and plastics, for turbidity control of liquids in a variety of



processes such as the manufacture of aluminum, and for turbidity control of gases, as in the examination of flue gases.

The densitometer projects two beams of light from a single light source. One beam passes through any standard filter; the other, through the filter or liquid the transparency of which is to be measured. The two light beams are then projected by an optical system to a single phototube. By means of an electronic and mechanical timing system, the instrument constantly measures the ratio of transparency of the sample as compared with the standard

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Photoswitch Inc., 21 Chestnut S Cambridge, Mass.

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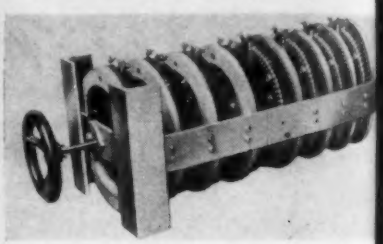

phases of a circuit by means of o knob.

Two rheostats can be separat controlled by means of concentrica located knobs to conserve panel spa or where it may be desired to use o rheostat as a vernier for another. this type of unit two rheostats a mounted in tandem with the shaft the rear unit extending through t hollow shaft of the front unit. F increased capacity, the front or ba units can consist of several rheosta connected together. Tandem rhe stats are also available in taper win ings and the same range of resi tance values as individual units.

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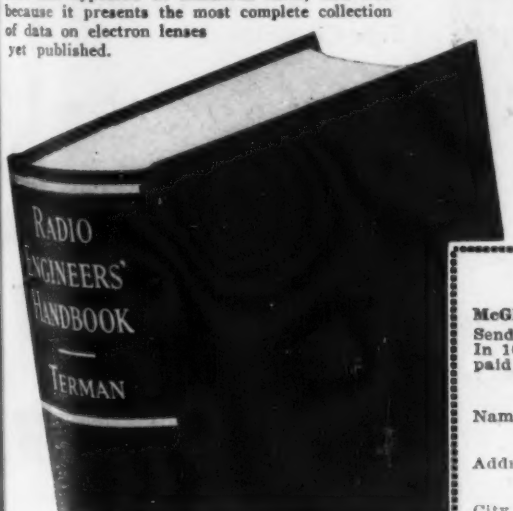

BY FREDERICK E. TERMAN

Professor of Electrical Engineering and Executive Head, Electrical Engineering Department, Stanford University (absent on leave), Director, Radio Research Laboratory, Harvard University

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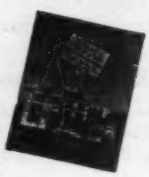

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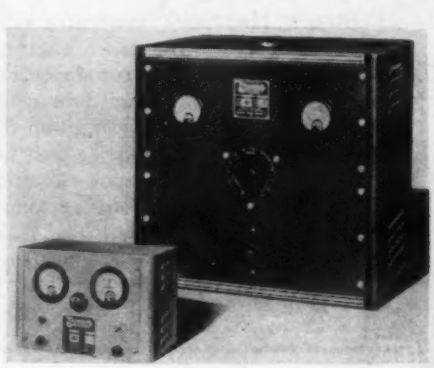
Other iron-core types for a wide variety of uses, and for frequencies to 175 Mc and better, are available from the manufacturer, Stackpole Carbon Co., Electronic Components Div., St. Marys, Pa.

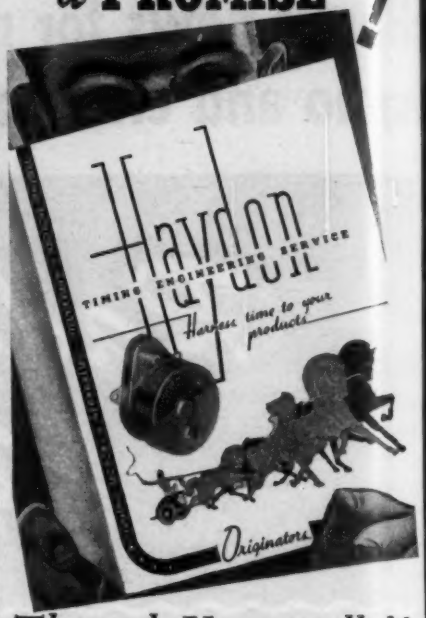
Battery Charger Line

THE MANUFACTURER'S selenium rectifiers are used to power these battery chargers which are available in a wide range of voltages and current ranges, as well as in individual designs for special applications. Three general classes of battery chargers are available. The first of these is a portable, low voltage type for automotive, aircraft, or radio uses. It features a wide charging rate control and may be equipped to switch from 6 to 12 volts with equal efficiency at



either voltage. The second unit is a communications type for telephone, telegraph, signaling and alarm systems ranging from 24 to 48 volts. The charger in this unit is provided with a filter to eliminate ripple. The third unit is a general utility type

An APOLOGY and a PROMISE !



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Our sincere apologies . . . we've tried to be patient, and hope you have too, but it is now really ready for mailing, after several months' delay in preparation. It's NEWER, more VALUABLE, and more INTERESTING.

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or central power stations, machine ools, control circuits and other gen- al requirements for 110 volts and . Chargers available are floating taper charge, multi-rate charging ith trickle end rate, and automatic egulated charging.

The selenium rectifiers used in hese battery chargers are a-c to d-c onversion units and are capable of harging batteries at either high or w rate. They provide automatic eduction of the charging current as he battery voltage increases, giving tapered charge which protects bat- eries from excess temperature or ndue gassing without the use of anual or automatic switching equip- ent.

General purpose power supply quipment is also available for owering production lines and for e as components of military equip- ent.

Selenium Rectifier Div., Federal elephone and Radio Corp., East ewark, N. J.

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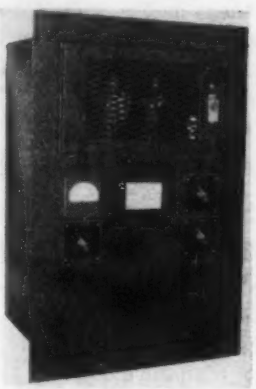
THE FURNATRON SYSTEM was de- eloped for applications where it is ecessary to keep to a minimum the ariations of resistance furnace tem- eratures. This is accomplished by ombining a thermocouple type of emperature controller with auto- atic control of the saturation cur- ent of a saturable reactor connected n the supply line of the furnace ele- ents, automatically controlling the ower input into the furnace.

The Furnatron may be used for urnace temperature regulation and ontrol of a single or three phase fur-



nace. Where the line or furnace ransformer voltage is not suitable to upply a-c to the thyratron tubes, an node transformer is furnished. An- ther optional feature is a droop cor- ector, which may be used in installa-

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Write for samples and further information.

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tions where the rate of material flow ing through the furnace changes thus compensating for heat exchange due to fluctuations in the rate at which the furnace is being loaded. The instrument also includes a compensator for line voltage variations. It is used to minimize the effect of fluctuating line voltage on high thermal inertia furnaces. The complete regulator is arranged for flush panel mounting. Protective devices of the system include a time delay relay, over-temperature mechanisms, surge suppressors, fuses and disconnecting devices.

Department 2-E-54, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Quartz Wafers and Optical Glass Etching Fluid

A NEW COMPOUND, known as "Quartz Etch", has been developed for etching quartz wafers and optical glass. The odor is mild, something like that of molasses, and no appreciable fumes are given off. Although rubber gloves are required in handling, casual contact with the skin is harmless, according to the manufacturer. No hoods are necessary, and ordinary galvanized metal tanks can be used. The manufacturer also states that fluid is vigorous in its action against glass or quartz, and cites as an example a user's report that a 40-minute immersion in the fluid produced a better pattern on a quartz wafer which was twinned than could have been obtained in several hours with hydrofluoric acid. Another advantage claimed for the new fluid is its effectiveness as an agent for finishing quartz crystals to frequency.

George W. Gates & Co., Hempstead Turnpike and Lucille Ave., Franklin Square, Long Island, N. Y.

Key Switches and Telephone-Type Jacks

KEY SWITCHES, designed for quiet operation in communications circuits, are available for immediate delivery with or without mounting plates. Allowing for a maximum of seven springs in each quadrant of the switch, they provide a wide variety of locking and non-locking switching combinations. Silver alloy contacts are standard. Special contact materials can be supplied when necessary.

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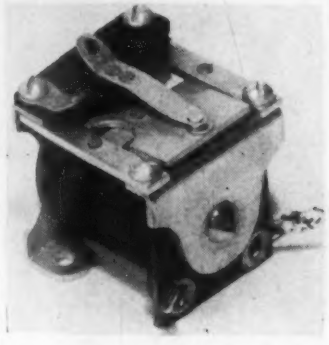
TWISTED LEAF SPRING takes the
ace of a pivot or pin-type bearing
this relay which measures approx-
ately 1 inch on each side and
eighs less than 1.4 ounces. The re-
y is designed to operate at 0.2
tt. The photograph illustrates a
rmally closed SP contact. SPDT
ntacts are also availale. Wiping



tion is accomplished by the use of
resilient mounting of the station-
y contact. The armature is mounted
the leaf spring, which twists, act-
g as the bearing as well as provid-
g the torque to bring the armature
its normal position after the relay
il is de-energized. Contacts are
ted at 1 amp at 24-volts d.c., non-
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Control Corp., 600 Stinson Blvd.,
inneapolis 12, Minn.

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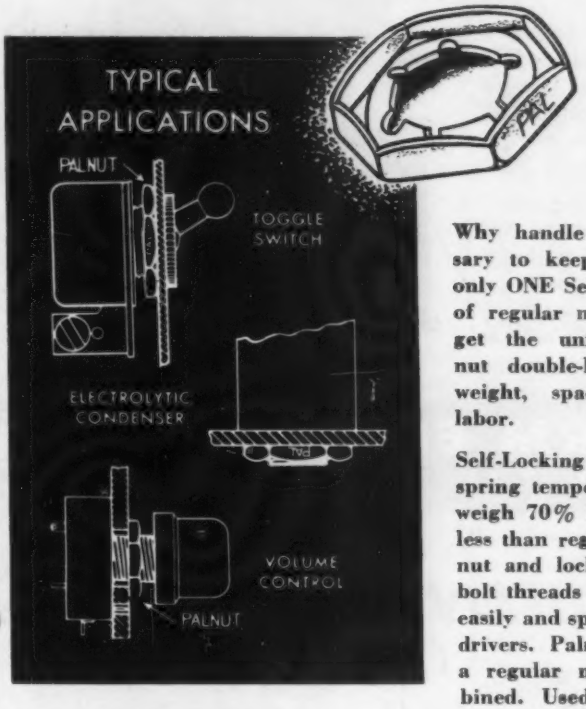

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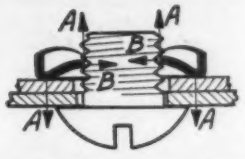

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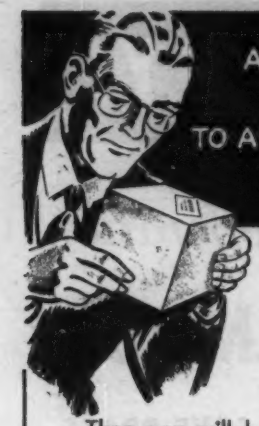

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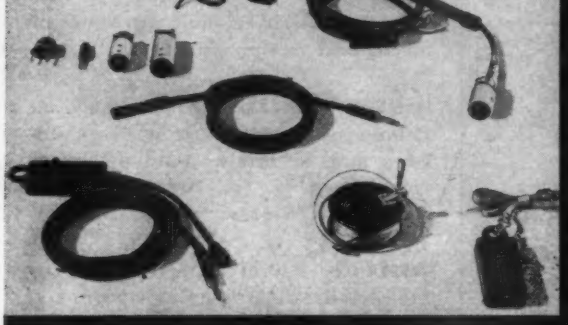

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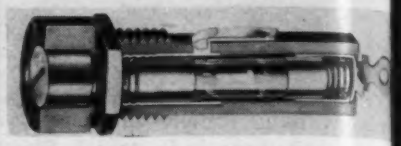
Extractor Post

To KEEP SIDE terminals of these ex tractor posts tight and secure agains heat and vibration, the manufacture has welded them to metal shells in side a bakelite body and backe them up with soft solder. The illus tration is a cutaway of No. 1075



extractor post. These posts are use with 3AG (1¼x¼ inches in diameter fuses for radios, fractional-hp mo tors, magnets, rectifiers, plate cir cuits, etc. Overall length measure 2½ inches; length from front panel i 2⅛ inches; mounting hole measure ½ inch. The maximum current ratin is 15 amp. It is available for screw driver operation meeting Underwrit ers' specifications, or for finger op eration. The knob and body ar molded of black bakelite and are im pervious to temperature changes an corrosion, and are insulated. Spacin between live parts gives protectio against electrical leakage.

Littlefuse Inc., 4747 Ravenswoo Ave., Chicago 40, Ill.

Bender

DEVELOPED FOR AIRCRAFT and marin work, the Di-Acro Bender No. 3 i

corporates all of the features of th manufacturer's smaller models (de scribed in past issues of ELECTRON ICS) but is heavier and more rugged and has a considerably greater ra dius-forming capacity. The photo graph shows a girl forming a pip support with this machine. A 7-inch circle and two right-angle bends ar obtained in one operation of bende No. 3. Bulletin 19-A is available.

O'Neil-Irwin Mfg. Co., Minneapoli 15, Minn.

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SMALLER . . . MORE COMPACT — THAT'S THE NEW AGASTAT, OFFERING EVEN GREATER DIVERSITY IN TIME DELAY SWITCHING. THIS ELECTRO-PNEUMATIC RELAY OFFERS THE SUPER-SENSITIVITY OF THE DIAPHRAGM TYPE INSTRUMENT, PLUS THE HIGH ADAPTABILITY OF AN INSTANTANEOUS RECYCLING UNIT. HEIGHT—FOUR INCHES, WEIGHT—ONE POUND, SEVEN OUNCES. MADE OF NON-CRITICAL MATERIALS THROUGHOUT EXCEPT FOR THE ACTUAL OPERATING MECHANISM.

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AMERICAN GAS ACCUMULATOR CO.

Heavy-Duty, High-Voltage Capacitors

AVAILABLE FOR MILITARY applications are heavy-duty, high-voltage capacitors which may be used in surge and lightning generators. The capacitors are equipped with solder seal terminals for operation at high altitudes and humid weather conditions. The unit illustrated is 28 inches high

and weighs 175 pounds. It is rated 0.5 μf, 50,000 volts, d.c., and according to the manufacturer is constructed to withstand 24 hours continuous operation and total submersion in salt water. Units for continuous operation up to 150,000 volts working are also available.

Industrial Condenser Corp., 1725 West North Ave., Chicago, Ill.

Literature

Engineering Data. Seven nonmetallic materials manufactured to meet the requirements of advanced product design are described in a 15-page booklet. The materials described are: vulcanized fibre, cotton cellulose material made in sheets and tubes; Dilecto, cloth fabric, glass fabric and asbestos grades made in sheets, rods and tubes; Dilectene, an aniline-formaldehyde resin product available in sheets and limited sizes of rods; Celoron, a molded fabric base phenolic plastic for mechanical parts; Micabond in sheets, tubes, and tapes of mica splittings bonded together with shellac or synthetic resins; Vulcoid, with good moisture resistance as compared to fibre; Haveg-Saran available in standard sizes covering a wide range of applications. The booklet also includes an application chart. Booklet available from Continental-Diamond Fibre Co., Newark, Delaware.

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A resistor is essentially an energy dissipator and as such it should be rugged. Since the demands of electronic circuits are quantitatively exacting, a resistor should be electrically and mechanically stable so that it will retain indefinitely its established resistance value at normal loading. A good resistor should withstand, without suffering a permanent change in resistance, the maximum accidental over-voltage to which it might be subjected in service. Moreover, it should be free from microphonic effects, inductance and capacity. It should have a comparatively straight line temperature and voltage characteristic and it should not be affected by humid atmospheres.

Globar Brand Resistors are built to meet these requirements.

This company was one of the first manufacturers of electronic resistors and today Globar Brand Resistors, steadfast against abuse, are serving as precision weirs in the electron arteries and capillaries of electronic circuits throughout the world. A trial in your electronic circuits will serve to verify these claims.

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PART NUMBER	WATT RATING	RESISTANCE RANGE	OVERALL LENGTH	OVERALL DIAMETER
997-A	1/5	150 Ohms to 4.7 Megohms	21/64"	7/64"
763-A	1/4	47 Ohms to 15 Megohms	5/8"	7/32"
759-A	1/2	33 Ohms to 15 Megohms	3/4"	1/4"
766-A	1	47 Ohms to 15 Megohms	1 1/8"	1/4"
792-A	3	22 Ohms to 150,000 Ohms	1 7/8"	15/32"
774-A	5	33 Ohms to 220,000 Ohms	2 5/8"	15/32"

TYPE "CX" RESISTORS

997-CX	1/4	1 to 150 Ohms	21/64"	7/64"
763-CX	1/2	1 to 47 Ohms	5/8"	7/32"
759-CX	1	1 to 33 Ohms	3/4"	1/4"
766-CX	2	1 to 47 Ohms	1 1/8"	1/4"
792-CX	4	1 to 22 Ohms	1 7/8"	15/32"
774-CX	6	1 to 33 Ohms	2 5/8"	15/32"

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ALL RESISTORS COLOR CODED According to R. M. A. Standards.
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Engineering Reference Data. This 36-page booklet has been made up for design engineers or the buyer of machine parts, in order to present clear and complete engineering reference data. Material described in this book are: hard vulcanized fibre in sheets, rods and tubes and in fabricated parts, Armite, an improved thin insulation (fish paper) in sheets, strips and coils; Spauldite, a laminated phenolic, in sheets, rods and tubes and in fabricated parts; Spauldo motor slot insulation; flexible fibre, a gasket material; fibre receptacles, boxes and barrels and fibre board. Booklet available from Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N. Y.

Colloidal Graphite. Bulletin No. 431-EE describes "dag" colloidal graphite for impregnation and surface coatings. It includes the reasons for colloidalization of industrial products and methods used to impregnate materials. Bulletin No. 431-EE is available from Acheson Colloids Corp., Port Huron, Mich.

Insulating Varnishes. Synthite PG-1 clear baking varnish for the protection of electrical units is described in a 6-page folder. This insulating varnish may be baked to any degree of hardness and does not resoften under heat developed by some types of units. A copy of this folder is obtainable from John C. Dolph Co., Dept. 22, 168 Emmett St., Newark, N. J.

Resistance Standards and Bridges. Bulletin 100 describes and illustrates standard resistors, standard shunts, mounted individual resistors, type B and type W decade resistance boxes, individual decade resistance assemblies, high-precision Wheatstone bridge, type B Wheatstone bridges, Mueller bridge, portable Wheatstone bridge test sets, high-precision Kelvin bridge, portable Kelvin bridge and limit bridges for rapid production testing. Bulletin 100 is available from Rubicon Co., Ridge Ave. at 35th St., Philadelphia, Pa.

Specification Finishes. Additional sheets to be added to Booklet 619, U. S. Government Finishes, are available from Maas & Waldstein Co., 438 Riverside Ave., Newark, 4, N. J.

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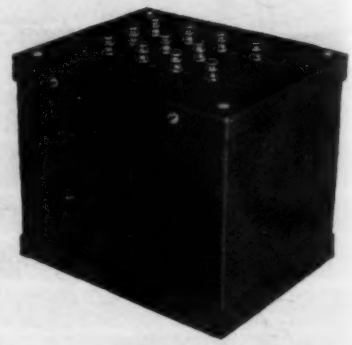
Acme electronic transformers are made-to-measure, for each application. That's why independent, unbiased tests give Acme first choice in performance. Acme engineers combine exact electrical specifications with mechanical limitations into precision-made transformers that provide for maximum performance of the electronic device.



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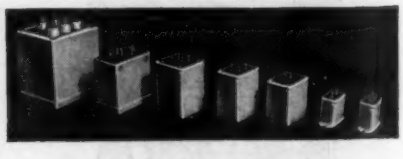

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imer on Radio. A 68-page primer help the beginner understand the ndamentals of radio. The scope he material is broad, with mathetical and engineering treatment fundamental theory held to a nimum. Copies available from Advertising Division, Electron- Dept., General Electric Co., idgeport, Conn., for twenty-five ts in coin.

rcraft Catalog. Catalog 36 pre- ts information on electrical con- tors for aircraft wiring. The alog consists of five sections: -kon terminals; wedge-on termis; tite-bind terminals; bonding npers; specialties. For those who eady have the first edition of s aircraft catalog, a complete of the new pages is available to ng their catalogs up to date. talog 36 is obtainable from omas & Betts Co., Elizabeth, 1, J.

stic Molding. Bulletin No. K-200 tains information on the custom lding facilities and services of a stic molding plant. The work of engineering, mold-making, proction and finishing departments described and some of the molded rts produced are illustrated. A le showing the comparative characteristics of various compression-lded plastics is included. Bulle- No. K-200 is available from perial Molded Products Corp., 25 W. Harrison St., Chicago, Ill.

zeltine Functions. In a 41-page ok, the Hazeltine Electronics rp. presents a broad picture of w the organization handles new velopments. One section of the ok is devoted to telling how some their electronic devices extend o many phases of life in war and ace. Copies of this book may be tained from Hazeltine Electron- Corp., 1775 Broadway, N. Y.

ectric Instruments. General Elec- ic's new publication "Electric Inuments, Principles of Operation" esents a discussion of the characteristics of instruments and what kes them operate, and individual itations of various types. Bulin GET-1173 is available from ws Bureau, General Electric Co., henectady, N. Y.

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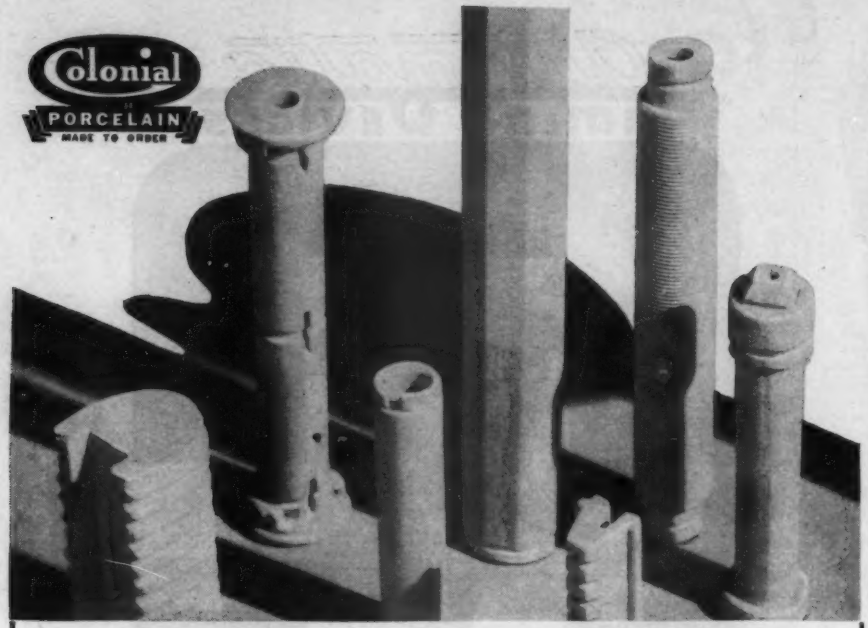

A-65-J, a New Refractory Tube Material

Above is tubing made from our new A-65-J material which gives special qualities to refractory tubing. A-65-J is made especially for wire wound enameled resistor tubing and is particularly well adapted for electrical control and radio use.

Glad to give you further information or quote on your requirements if you will send us specifications or drawings.

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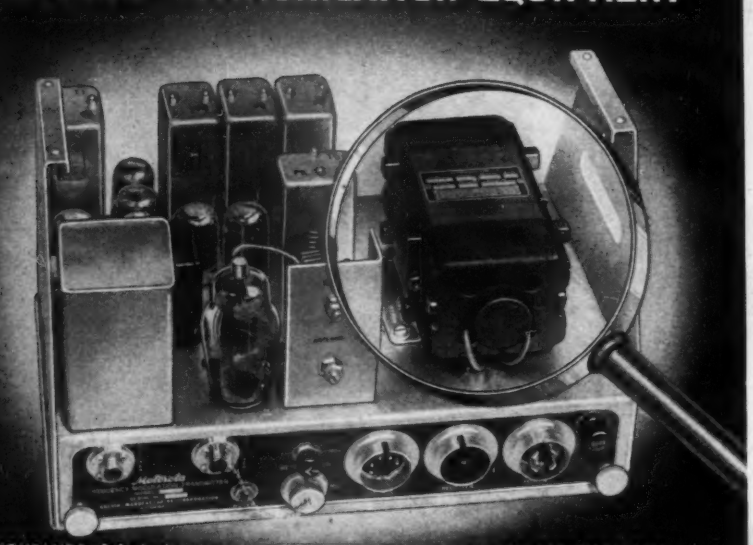

THOUSANDS of these Carter Original Genemotors are constantly providing that something "extra" in MOTOROLA'S famous FMT-30D Mobile FM Radio transmitter, pictured above. Why not submit your requirements and become acquainted with this preferred Power Supply?

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Primer on Electronic Tubes. "H... Electronic Tubes Work" is a ... page nontechnical book. Bulle... GEA-4116 is made up chiefly for ... dustrial engineers. The prime... main emphasis is on how the el... tronic tube operates. The ei... basic types of industrial electro... tubes and their uses are describ... Bulletin GEA-4116 is availa... from Dept. 6-215, Publicity Di... sion, General Electric Co., Schen... tady, N. Y.

Fuzed Quartz. A price schedule ... fused quartz for standard sizes ... ingots, rods and tubing is availa... from the address below. The fu... quartz comes in a variety of si... both clear and translucent, wh... are also listed on the price list. T... physical properties and charact... istics of fuzed quartz are describ... in a reprint from an article by P. ... Devers published in *Light* magazi... Send request for above to Mr. P. ... Devers, Lamp Dept., General El... tric Co., Cleveland, 12, Ohio.

Level Controls. A four-page bul... tin containing information on el... tronic level controls for liquids a... powders. Bulletin available fr... Photoswitch Inc., 77 Broadw... Cambridge, 42, Mass.

Spot Welding Machines. Bulle... 93-W-43 covers the operating pri... ciples, typical standardized arran... ments and special applications ... small spot welding machines. Se... eral welding tips and fixtures, illu... trations of automatic welding ti... ers and contactors and types ... transformers manufactured by th... company are covered in the bookle...

Bulletin 92-BW-2 lists feature... applications, and operations ... types and sizes of small and heav... duty butt welders. These welde... are particularly designed for wel... ing wires as small as 0.008 i... diameter of tungsten, molybdenu... nickel and copper. Examples ... butt welders combined with co... tactor and timer suitable for wi... drawing plants are also shown i... this manual.

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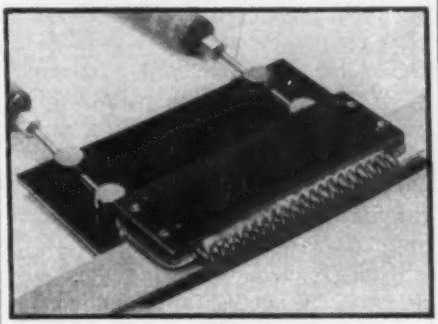
AMERICA'S STANDARD FOR OVER 30 YEARS

Work Coils

(*Continued from page* 112)

encompass only a portion of the object, or by allowing only the desired portion of the object to project into the coil between its turns.

High-frequency heating permits accurate control over what is heated, how long it is heated, and how much it is heated. This means that inexperienced operators can obtain uniformity of heat treating on production runs far more readily than with conventional heating methods. Once a satisfactory work coil has been constructed and the optimum frequency and time determined for it by experiment, heat-treating merely involves placing the metal part inside the work coil, stepping on a foot control switch for the requisite number of seconds, then either turning on the water spray device which surrounds the coil or removing the part and dropping it in a quenching solution. Asbestos strips or other means can be used to center the object with respect to the coil. The depth to which heat penetrates can be regulated to a small fraction of an inch regardless of the thickness of the object being heated.



Work coil for annealing continuous strip prior to hot stamping and forging

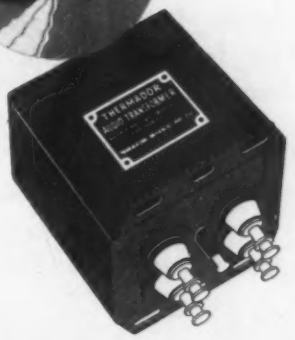
Brazing and soldering by means of induction heating give uniform penetration of heat throughout the joint to be brazed or soldered, eliminating excessive heating on the surface and leaving very little discoloration and practically no scale. Thus, cleaning or refinishing operations can often be omitted. The electronic process also eliminates waste of excess solder or brazing alloy, a vital factor in wartime. The temperature produced is essentially a matter of time, with heat becoming progressively more

Defeats

HEAT

COLD

HUMIDITY



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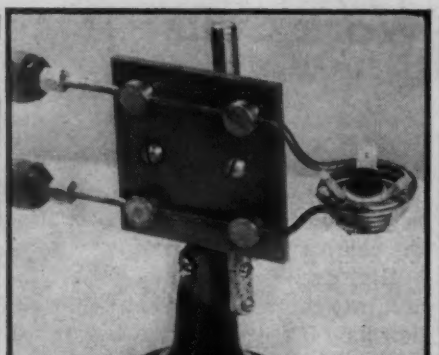

Cone-shaped work coil for heating the teeth of a bevel gear preparatory to hardening. The gear is automatically centered by the asbestos strips. The coil is mounted on a movable stand

intense as current is left on, hence brazing alloys right up to those with the highest melting points may be used.

Melting of small masses of metals can be accomplished readily with a small crucible placed inside a work coil. If a conductive graphite crucible is used, most of the heat is generated in the walls of the crucible and is transferred to the metal by conduction. With a ceramic crucible, the high-frequency current is induced in the metal itself, causing a stirring of the mass of molten metal which gives a high degree of uniformity to the melt. The metal can be poured with power on, which practically eliminates freezing of metal at the lip of the crucible.

High-frequency heating has already been successfully applied to several thousand war production problems. The field of economical commercial uses is just being discovered and opened up.—J.M.

ANOTHER FIRST—100,000,000-volt x-rays were produced for the first time on Aug. 21 by the G-E research laboratory, using the recently completed induction electron accelerator. The first few observations show that the characteristics of these x-rays differ radically from those with which physicists are familiar.

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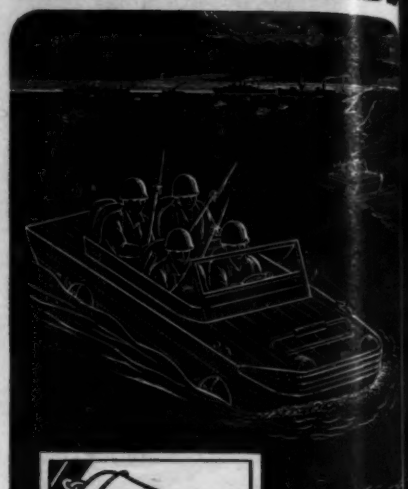

BELL SOUND SYSTEMS

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The quick change to skilled production of new and complex wartime electronic devices at BELL Sound Systems was not due to ingenuity alone. It was a result of technical preparation. Bell Engineers have always made a point of keeping ahead of today's sound equipment needs. Their research, study and experiment — plus Bell's advanced production experience—gave them a valuable head start on war's new requirements. This aggressive policy is permanent. It will give Bell Sound System engineers just as big a head start on new peace time needs for electronic sound devices and related equipment.

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first to be designed specifically for industrial use — are typical of BELL'S leadership. Compact, integral units combine readily to meet any distribution or capacity need. They provide for plant-wide music, announcements, vocal paging, warning or work signals, and other services. Write for complete details today.

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Short-Wave Control Center

(*Continued from page* 117)

Two special small rooms are provided especially for transcription broadcasts. In these rooms are three individual turntable channels, each equipped for electrical spotting. During use, a turntable motor runs continuously. The pick-up is set at the desired point on the record while the record is held stationary by an electromagnetic brake, so that the record slips on the turntable until the release button is pressed at the instant the program is to start. In this way the operator in one of the transcription rooms can start three separate transcribed programs simultaneously following a station break.

In addition, there is an announcing microphone in each transcription room, along with complete testing, cuing and monitoring facilities. All microphones used by OWI in New York City at present are Western Electric type 639 cardioid models.

Recording Room

The recording room is believed to be the largest in the world. In it will be 20 complete Memovox machines running continuously and providing embossed recordings of all programs going on the air, for future reference. The machines oper-

One of the 16 control rooms serving the 16 live-talent studios in the new OWI master control center in New York City

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REDUCES HEATING COSTS MORE THAN 30% PER YEAR ON DEGREE DAY BASIS
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Proves savings affected since Flashtron was installed in steam heating control system, by records made available through meters double checked for accuracy, by both themselves and utility company supplying steam.

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Every day we are approaching nearer to the time when advancements in television, radio, aviation and electronics in general, can be parts of everyday life. When this occurs, products which have materially aided the forces of Victory, will come into their own once again. This time as a human betterment.
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Inquiries pertaining to post-war intent—and applicable to our plant capabilities for caps, bases, television tubes and three great types of leads—are invited. Blueprints, sketches, or data sent to us for consideration or collaboration, will be treated in strict confidence.
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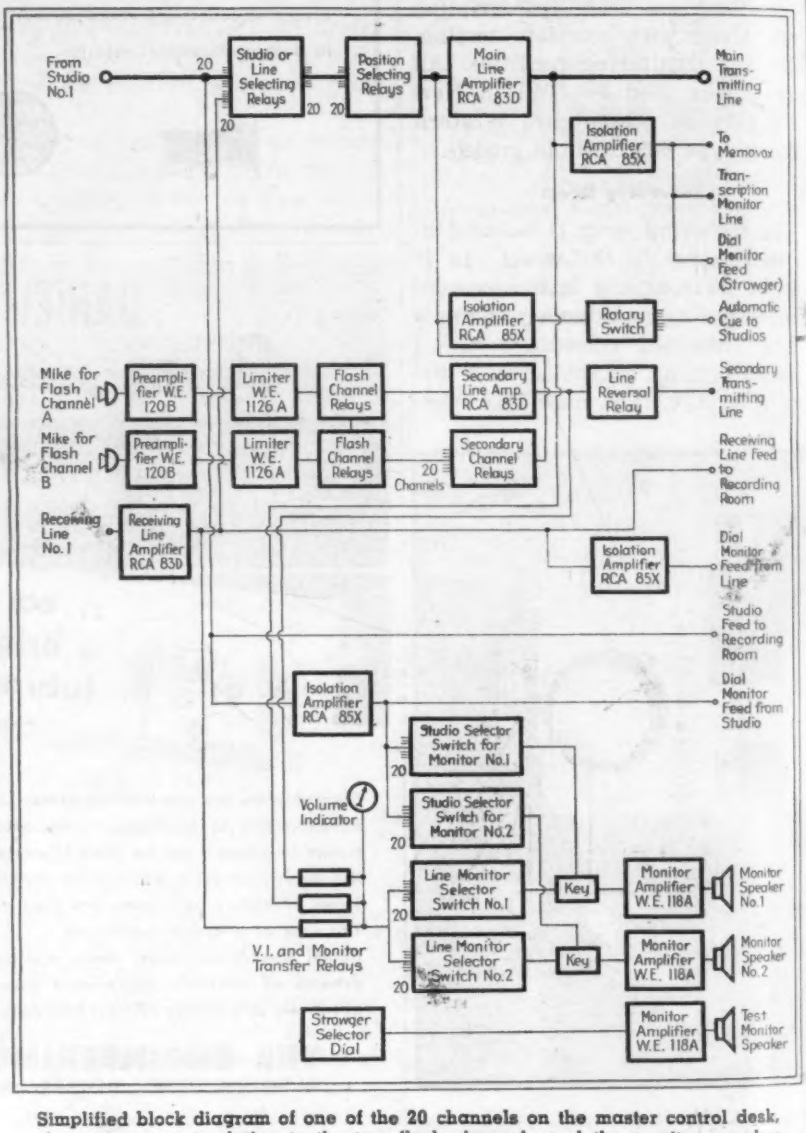
ate automatically off channels on the control desk, in such a way that whenever a channel is placed in operation, its corresponding Memovox unit starts up. Each Memovox unit contains two turntables, with provisions for automatic switching from one to the other to provide a total of two hours continuous recording without attention. Flexible plastic disks of ethyl cellulose are used here, each being about one-sixtieth of an inch thick. A one-hour program can be embossed on each side of each disk. Constant-velocity drive is used in embossing, to give the same frequency response at all points on the record. Crystal cutters are used, and rough estimates indicate that frequencies up to 5,000 cycles are recorded with this equipment.

Each Memovox unit has its own monitoring loudspeaker, with a pick-up riding directly behind th cutting head. The loudspeaker can b connected across the cutting head hear what is going into the recorde or can be fed by the pick-up to chec the recording equipment.

Also in the recording room are RCA type 73A recording lathes wit automatic equalizers and high-fide ity cutting heads, used to provid high-fidelity transcriptions for fu ture rebroadcasts. Each lathe is rub ber-mounted on a 700-lb block of con crete which in turn is rubber mounted on the floor of the recordin room. At each lathe is a control bo that permits individual, simultaneou or consecutive operation of a pair o lathes automatically in recording program for future rebroadcast, fo sending to stations not connected b wire lines with the studio, or for con version into pressings to obtain



Simplified block diagram of one of the 20 channels on the master control desk, shown in correct relation to the two flash channels and the monitor speaker channels that serve the entire desk

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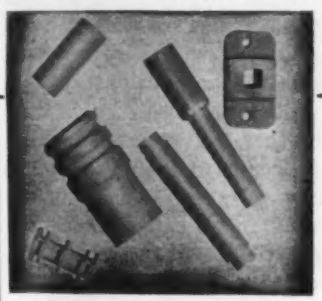

CHARACTERISTICS

Specific gravity of only 2.5 to 2.6. Water absorption S. 1.5-0.001 per cent. Per cent power factor. S. 1.5 to 60 cycles was only 0.0165. Dielectric constant at 60 cycles was 5.9-1000 KC 5.4.

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large number of duplicate recordings for rebroadcast from foreign locations.

Chips are removed during recording by a vacuum system located in an adjacent room and connected to each recording location through stainless steel tubing. The chips are deposited in a water tank in the adjacent room, and the cleaned out twice a week.

All programs going through the master control desk also pass through the master recording control desk in the recording room, permitting instant selection of any desired program and routing of it to any recording lathe that is free.

Serving the 14 recording lathes in the recording room are 14 racks of equipment, containing 14 Western Electric type 105 program amplifiers, 16 Western Electric type 118 driving amplifiers and 14 Western Electric type 1087 power amplifiers. With this equipment, recordings are made regularly that provide frequencies up to 10,000 cycles during playback.

With each lathe having its own monitoring loudspeaker and with a total of 40 loudspeakers in the Memovox unit and two more loudspeakers mounted on the wall for general monitoring in the recording room, it is possible to have a total of 56 loudspeakers in operation at one time in the recording room. The normal output of this room will be approximately 100,000 disks per year.

Status of Project

Technical facilities are now approximately 60 percent completed at the master control center. The recording room is complete except for 7 Memovox recorders now being manufactured. Most of the constructional work remaining to be done is on the master control desk, with delays here being due in some measure to difficulties in securing certain required parts. Nevertheless, the control center has been serving its transmitters for some months already, with switching being accomplished normally by means of 100 patch cords on emergency operating panels provided in the master control room for use in case of control desk failure.

Initial construction work was under the direction of Carrol Hauser, now with the Washington office of the OWI Bureau of Communication Facilities. The project is being completed under the direction of George W. Herrick.

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For parts up to 10 lbs., 25 lbs., 100. lbs.
Manual frequency change.
Automatic frequency change.

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Electronic Curriculum

(*Continued from page* 124)

of alternating-current machiner electric power transmission and di tribution, communications networ or transmission lines, communic tions applications of electron tub or electromagnetic radiation a propagation, it includes two subjec especially designed for the opti electronic control and measureme and electrical implementation, wi associated laboratory work. This o tion likewise provides for profe sional electives and a thesis.

The professional electives a scheduled one in each of the t terms of the fourth year. They m be selected by the student from group of specialized electrical eng neering subjects. Other subjects, the fields of mathematics, physic mechanical or aeronautical enginee ing, or economics also may be cho as professional electives by spec arrangement. For example, a stude in the electronics option might stu additional fluid mechanics. In cho ing the professional elective, the s dent may either increase his speci ization by choosing subjects wh emphasize the trend of his option, he may broaden his outlook by cho ing subjects which are related m closely to other options than to h own option.

The thesis is expected to be in t special realm of the option which t student pursues, and in general expected to be experimental as w as analytical, and frequently may i corporate economic studies.

Degree of Specialization

Since the word "specialization" h been used, and since the division engineering education into cours and then still further into optio means to many persons not mere specialization, but over-specializatio that ghost should be laid by taking final backward view of the curricu outlined. Such a review indicate (1) the curricula of the three option are identical through about 80 pe cent of the range, and (2) the di ferences in the curricula are on differences in illustrative applic tions of principles studied in all t options. All the curricula are solid

grounded in scientific principles from start to finish, and none is specialized in the sense that it is substantially concerned with passing commercial or technical practices. The apparent specialization has the advantage of capitalizing upon the natural interest of students so as to give greater drive to their study of principles.

The special subjects, electronic control and measurement and electrical implementation, and the associated laboratory work, in which the electronics option culminates, have been under development for only a few years and therefore have not reached the steady state. However, the transient state often is the most interesting and educational to student and instructor alike. In fact, most academic subjects unless exposed to an occasional new impulse drift into the doldrums. Though the subjects about to be described have the educational advantages that accompany the transient state, they are still definitely on the underdeveloped side and so afford a fertile field for investigatory and research work.

Electronic Control

The work in electronic control and measurement is organized to cover the more important functional methods whereby electronic devices are employed in control and measurement applications. A study of the uses of electronics in laboratory and industrial equipment indicates that the electronic devices in most of the equipment can be classified as functional elements under a relatively small number of headings. Among these headings are rectified-power supplies, voltage stabilizers, modulators, amplifiers, detectors, grid-controlled rectifiers, oscillators, trigger circuits, inverters, sweep circuits, stroboscopes, oscilloscopes, and indicator tubes. The topics discussed correspond, for the most part, with the foregoing headings. Various combinations of these functional elements make up a multitude of useful devices; for example, sensitive voltmeters, ammeters, and watt-meters, voltage and speed controls, remote indicators of various types, spot-welding timers, and high-speed graphic potentiometric recorders.

With a few exceptions such as the oscilloscope, stroboscope, and electron-ray indicator tube, which may be called electronic instruments in themselves, the strictly electronic

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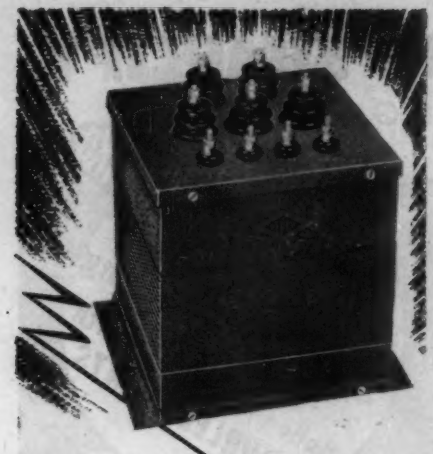

New War Techniques Will Improve Peace-Time

PEERLESS

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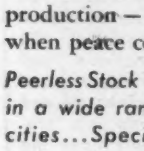
Peerless Transformers already embody such features as the exclusive Vac-Sealing process, hermetic sealing, new compound treatment, more lasting finishes and an improved winding technique. Plant facilities have grown and new die making machines add to production — all ready for your needs when peace comes again.

Peerless Stock Transformers are available in a wide range of designs and capacities...Special Transformers will be built to your specifications.



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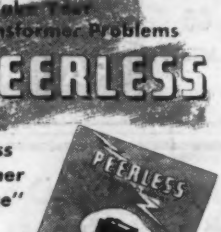

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part of most electronic apparatus is a means to an end, one link in a chain, but neither the beginning nor the end. Hence, for useful engineering application, the foregoing functions of electronics are not complete. They must be supplemented by nonelectronic conversion devices at the beginning and end of the chain. Thus in a large number of control and measurement applications a stimulus, which is often nonelectrical in nature must be made to actuate some device such as a meter, motor, or solenoid valve which gives an indication of output suitable as a measure or for control. Typical systems of components in electronic devices are shown in Fig. 1. Hence the electrical problem of conversion of such stimuli as light, temperature, level, pH, position, elongation, and vibration into an electrical quantity suitable for operation of the electronic device is an important problem in this field of electronic applications. Correspondingly, the conversion of the electrical output of the electronic system so as to obtain a chart, pointer movement, or shaft rotation is also an important problem. Many of these conversion problems, and the behavior of the corresponding conversion devices, are discussed in the work on electrical implementation. Others are treated in electronic control and measurement.

An example of an electronic measuring instrument containing a number of functional elements is a particular recording potentiometer. In this device a voltage derived from a source such as a thermocouple drives a motor which, in turn, operates a slidewire so as to maintain balance in the potentiometer circuit. For ease of amplification, the unbalanced direct voltage of the potentiometer is first converted to alternating current through modulation by a time-varying resistor—a carbon-button microphone vibrated by a 60-cycle-per-second solenoid. An alternating-current amplifier supplied by a rectified-power supply amplifies the converted unbalanced voltage. Before it can operate the direct-current motor, however, the amplified unbalanced voltage must be reconverted to direct current. This conversion is accomplished by a pair of thyratrons acting as grid-controlled rectifiers. By this chain of elements, balance is accomplished with a speed that is not even approached by nonelectronic re-

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ding potentiometers. The operat- parts of such a potentiometer are wn in Fig. 2.

Electrical Implementation

n the subject electrical implemen- on, the over-all behavior of sys- s involving electrical and non- trical interrelations, including minal or internal energy conver- s, are analyzed. The systems ex- ned may or may not contain elec- ic elements. Many systems are lied by the use of electric-circuit logies and models. This method be used for any problem the ations of which may be taken to resent electric-circuit equations ely by proper redefinition of sym- . The method of electric-circuit logy is not used exclusively, be- e it cannot be applied to all types problems encountered, and because s not always advantageous even n applicable. However, the situ- ons in which the method is both licable and advantageous are so erous that substantial emphasis he method seems warranted.

he method of electric-circuit an- gy can be applied to problems in hanics, hydraulics, heat flow, ac- tics, and especially to problems erein electrical and nonelectrical nomena are interrelated. Exam- include the mechanical behavior turboalternators, of spring-and- k-absorber systems, of governors other control mechanisms; the of water or other liquids in es; the flow of heat in walls of dings, furnaces, or ovens; the gn of sound-recording and sound- roducing apparatus; the trans- ion of sound in tubes; the be- ior of various electrical or me- nical instruments and relays, in- ding seismographs; the behavior magnetostriction oscillators and oelectric crystals. The method is ecially advantageous when it can used to analyze the over-all be- ior of an electromechanical, elec- hermal, or electrothermomechani- system consisting of a chain of ious devices.

he analysis of a purely nonelec- al problem by the method of elec- -circuit analogy has no advan- e beyond an apparent clarifica- from the point of view of one oled to think in terms of electric- uit quantities rather than in ns of analogous nonelectrical

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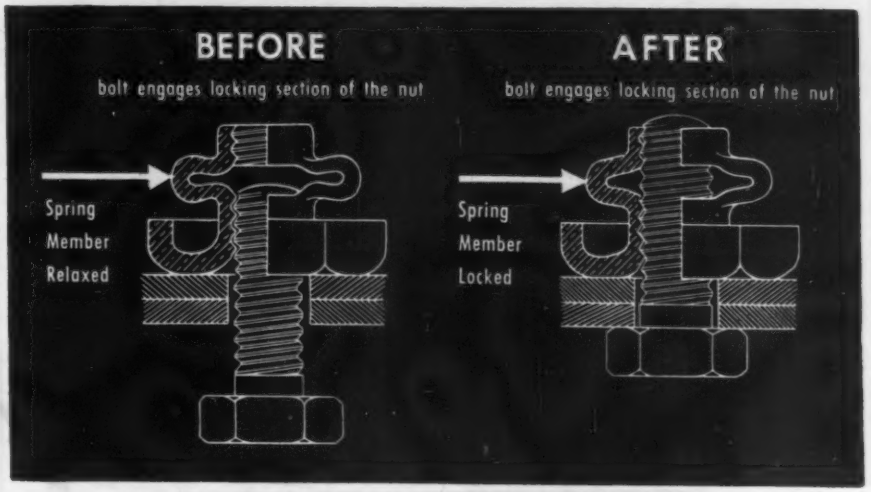

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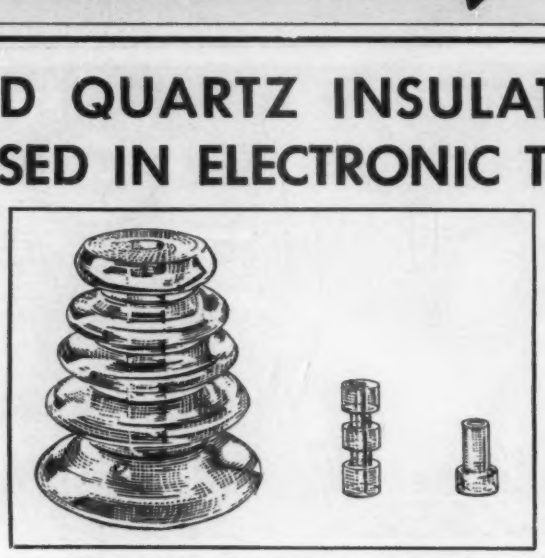

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quantities, and the possibility of e cise diagrammatic representation the problem by means of electric-c cuit symbols. For a problem wher electrical and nonelectrical phe mena are interrelated, analysis the method of electric-circuit alogy has the considerable advant of reducing the problem to a sin set of terms and symbols, and a s gle diagram by means of which interrelations can be more read visualized than from the separ equations and diagrams for the el trical and nonelectrical parts of system. Analysis by the meth of electric-circuit analogy to point of determining what t of electric circuit to use is a preli inary to the development of an el tric-circuit model.

Use of Models

In general, the proper use of m els affords a comparatively in pensive means of studying the havior of expensive structures or paratus in the design stage so as make the ultimate design as near optimum attainment as is reasona feasible, or even so as to avoid p sible disaster in the ultimate c struction. Models also may be used predict the behavior of existi structures or apparatus if modifi or used under conditions that d not be risked on the actual struct or apparatus. Electric-circuit mod especially possess the advantages cheapness, flexibility and ease of sembly, ease of control over test c ditions, speed of response, and curacy of measurement. For exa ple, the study of heat losses fr buildings for various insulating structural materials used in vari combinations and distributions der various temperature condition prohibitively costly of time, lab and materials if carried out on act full-sized buildings, and is larg dependent on weather for tempe ture conditions. The use of therm models reduces the time, labor, material requirements very subst tially; but even so, the thermal mo presents certain intracacies of c struction, lack of flexibility in sembly, sluggishness of temperat control and response, and difficult of measurement largely absent in electric-circuit model. The electr circuit model consists merely of collection of resistors and capacit

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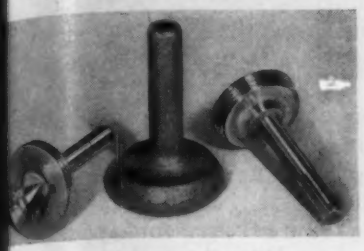

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The circuit of Fig. 3 can be used to study the thermal behavior of a house in considerable detail. Through introduction of grosser approximations, the circuit can be considerably simplified, but simplification to the extent that makes analytic solution practical discards the possibility of obtaining considerable valuable information, and affords no advantage that could not be derived from an analytic attack directly in thermal terms. Therefore, the use of an electric-circuit model is desirable. The principles of behavior of the resistance-capacitance network are elementary, but the design of voltage and current sources and proper switching devices for simulating the outdoor and indoor temperature variation or heat supply, and the problems of measurement require considerable ingenuity and may well involve electronic devices. Here then is a simple example of a problem fundamentally of a nonelectrical nature advantageously attacked by the method of electric-circuit analogy and the use of laboratory models involving electronic devices.

In both of the subjects outlined, commercial apparatus is used to a considerable extent for the illustration of principles. However, the objective is not a study of commercial apparatus, which may be outmoded in a few years, but is the study of the functions which the devices may serve, and the characteristics and limitations of the devices in serving these functions. This study is carried on not only analytically, but also experimentally. In the laboratory, initiative, resourcefulness, and a feeling for experimental solution are developed in the student through encouraging him to plan his own program of experiments.

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Electronics 10-43

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Sensitive Relays

(*Continued from page* 127)

minimum value for G_s (the air gap when energized) recommended by the manufacturer for the conditions of the problem. The G_s line may therefore be drawn at this point. If there is a definite requirement for drop out, mark off on line G_s the point where it is crossed by the curve for desired drop out power, and draw horizontally through this point the line representing the force of the spring, which will be set to this value.

Bear in mind that what we have done in drawing G_s at a particular point is to say where we shall set the normally open contact, and hence how close to the core we shall allow the armature to travel. Further in deciding on the drop out value we have said that with the armature in this particular position, the spring shall be adjusted to a value such as to equal the magnetic force at the specified drop out value, so that when the power falls below this value, the spring will restore the armature to its normal position.

Where shall the normal position G_n be? It must first be far enough away from the G_s value to permit the contact separation demanded by the particular problem. In addition as long as the spring is not again changed, position G_n controls the value of power at which the relay pulls on. Pull on will occur at the value of power corresponding to the curve which goes through the intersection of the spring line and G_n line.

Having drawn the G_n line, there remains only to complete the cycle by drawing in the curves corresponding to pull on and drop out values, in case either or both are interpolated values.

3. Inspection of this cycle will disclose whether the requirements of the problem are met. In case they are not (suppose, for example, inadequate contact pressure exists immediately after drop out), the possible remedies will usually be obvious. *The most important thing is that the exact effect of any amount of any particular adjustment can be read off the graph as soon as tentative values for some of the others are chosen.*

In the adjustment of a sensitive relay there are five main variables which may be "independent." That is, any three of them which will locate two points on a cycle can be chosen independently and will fix the other two, subject to deviations of individual relays from the performance of the one for which the curves are plotted.

Specifying a Relay Adjustment

The five variables are: 1. Pull on; 2. Drop out; 3. Spring force; 4. Minimum pole gap (G_p); 5. Armature travel or contact gap ($G_a - G_p$ = Travel).

Having specified to appropriate tolerances the values for three variables from the list, one may ask a relay manufacturer to recommend suitable values for permissible variation of the other two. In any case, he must be consulted on this point, for in adjusting the relay he can work for only three.

• • •

ELECTRONIC STITCHING MACHINE

The operator is shown placing a tube into an electronic welding timer at the Pittsburgh plant of the Westinghouse Electric & Manufacturing Co. "Package units" such as this welder have done much to bring electronics to the attention of the industrial user. The welder has been likened to a "sewing machine" and the spot welds for making sheets of aluminum or steel adhere to one another have been likened to the stitches

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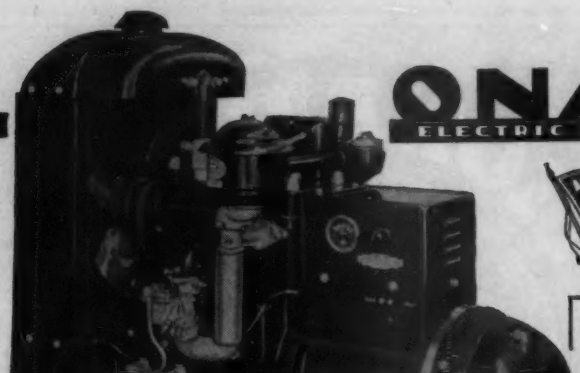

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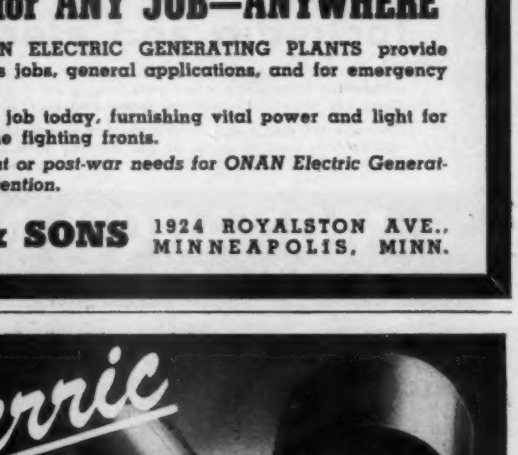

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D-C Motor Control

(*Continued from page* 133)

the reverse direction from that in which the motor is then rotating. The control will cause the armature circuit to be reversed, the thyratron tubes to act as inverters, and the rotational energy of the motor and its load to be pumped back into the a-c system just as on a normal reversal, except that as the motor speed passes through zero, the armature thyratrons will be turned off completely and the motor will remain at zero speed. If the motor is driving a high-inertia load and is being stopped from a high speed, the armature tubes might not be cut off exactly when the motor speed reaches zero and the shaft might make one or two rotations in the opposite direction before coming to rest. In this case, a slight modification of the control scheme will cut off the thyratrons slightly ahead of zero speed to anticipate stopping at zero speed.

Dynamic Braking to a Stop

When it is desired to stop the armature more quickly than it would naturally coast to a stop, either a mechanical brake or dynamic braking, or both, can be used. Dynamic braking consists of disconnecting the armature from the d-c supply, which is done by phasing the armature thyratrons full OFF or by opening the circuit of the reversing contactors and connecting a resistor across the armature terminals so that the generator action of the motor (its field must be excited) will dissipate its mechanical energy in the form of electrical watts of heat in the resistor and thereby decelerate the motor. It should be remembered that at first the braking action is greatest when the armature voltage and current are greatest; but it falls off quickly as the motor speed decreases and armature voltage cannot be maintained at these high levels. It is the mechanical friction which finally stops the armature.

Rapid Deceleration, High Speed to Low Speed in the Same Direction

Some applications, like those involving high-production processes where time is valuable, or profile fol-

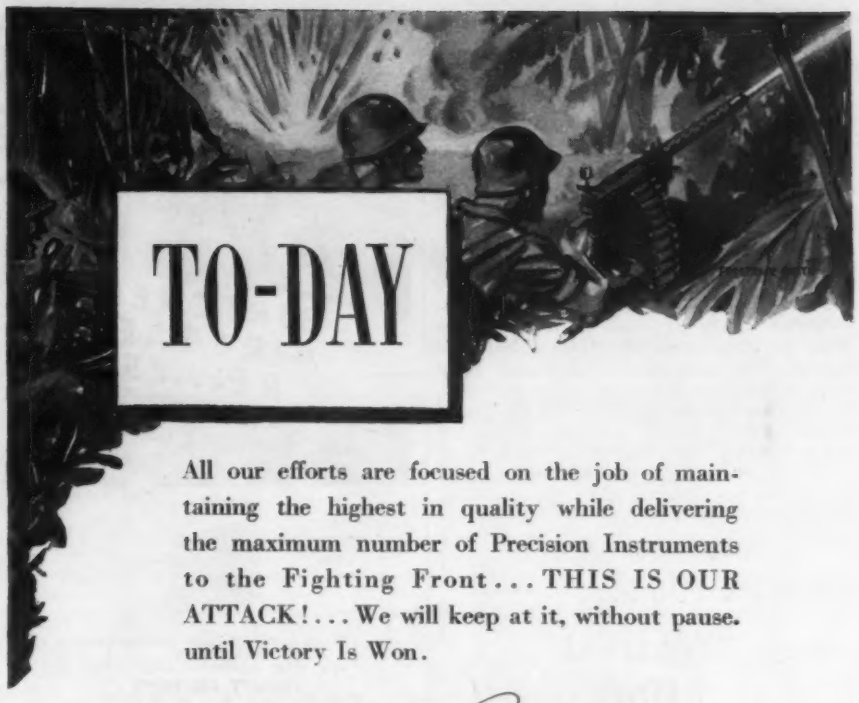
lowing where quick response to a signal is important, make necessary a rapid decrease of speed, following a signal calling for operation at a lower speed level.

In many instances, it is only necessary to apply dynamic braking until the lower speed is reached, and then remove the braking effect. This can be accomplished quite simply by a triode (tube K of the "Quick slowdown circuit" of Fig. 3) which controls a small relay (CR_2 in Fig. 3) whose contacts (normally-open, in this instance) control a dynamic-braking contactor (DB) for the armature circuit. This added triode, tube K, takes a measure of the signal voltage applied to the grid of tube D which controls the saturation of the armature saturable reactor. Since tube D is turned off by a signal which calls for a lower armature voltage (as by turning the armature voltage control potentiometer to a lower-speed position or switching to a similar potentiometer preset for a lower speed) and stays off until the armature voltage has reached the new, lower level, so too, will tube K do likewise except that the added positive bias which separates the grid of tube K from the grid of tube D causes tube K to be a little more turned-on than tube D so that its relay will not be chattering during the normal operation of tube D.

A signal which calls for a slower speed will turn off tube K, drop out CR_2, drop out DB and apply dynamic braking via the contacts of DB (normally-closed, in this instance) and the dynamic-braking resistor DBR, and will have already cut off the armature thyratrons. When the speed has been decelerated to the new, low level, the armature voltage will once again cause tubes D and K to conduct current in a normal manner so as to energize relay CR_2 and discontinue dynamic braking, and at the same time turn on the thyratron tubes by the proper amount to drive the motor at the new speed level.

Application to MG Set Drives

For motors of 50- to 400-hp rating and above, it is practicable to modify this equipment so that the thyratron functions associated with variable armature excitation of a 1- or 3-hp motor can, instead, provide field excitation for the generator; the thyratron functions associated with the variable field excitation of the small



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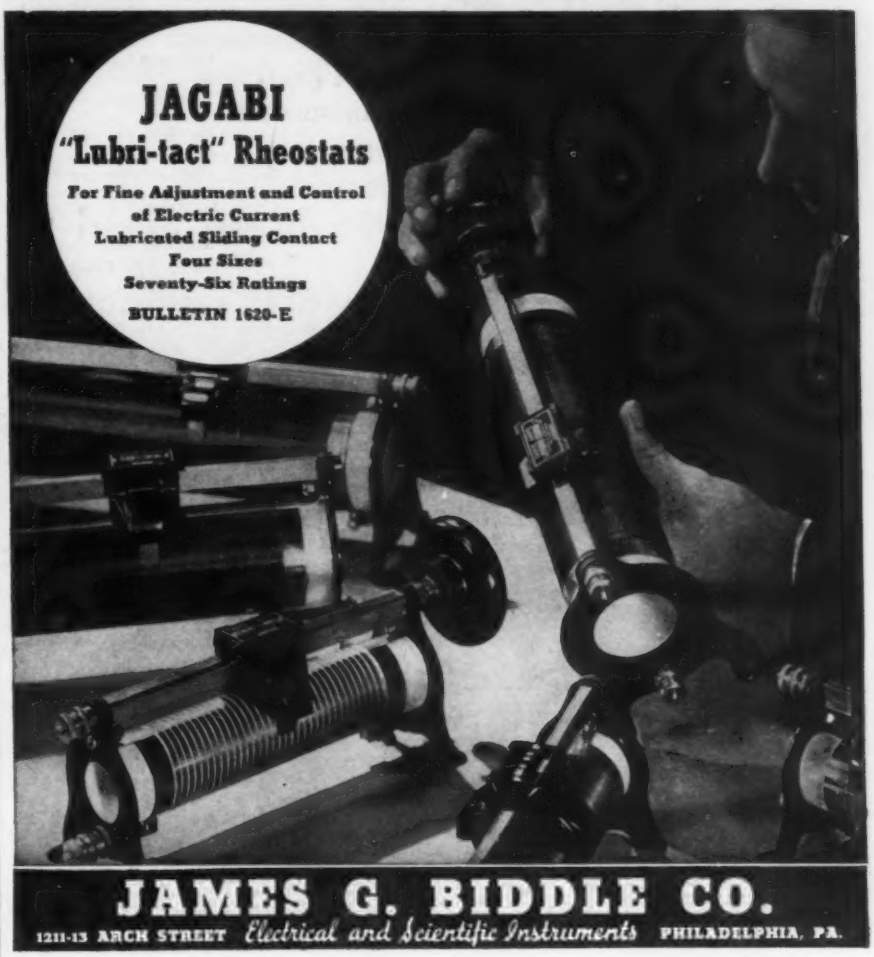

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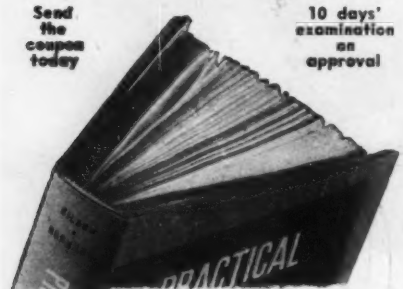

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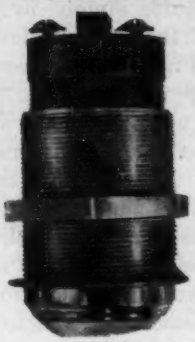

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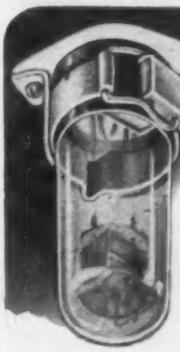

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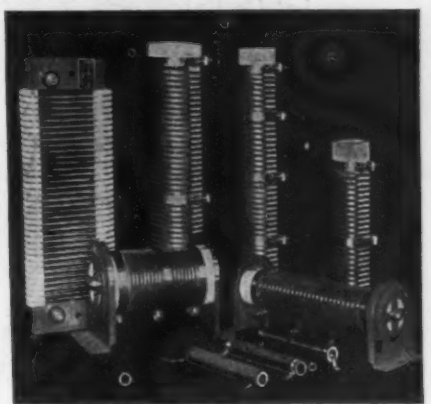

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motor can be adapted to supply field excitation of the large motor. Armature current control (loop current in this instance) becomes more complex, particularly since direct current must be measured directly and its direction ascertained so as to give correct sequence of excitation to the respective fields of generator and motor during acceleration and deceleration. The reversing problem, too, is more complicated because of the necessity of reversing generator field excitation, but all this has been done.

Control Equipment

A typical control panel and push-button station for a 1-horsepower, 230-volt motor is shown in Fig. 4, while Fig. 5 shows a rear view of the same Thy-mo-trol panel. The control unit, or "brains", is a separate sub-panel assembly (Fig. 6) which is attached to the main panel and connected to the circuit of the main panel by means of a plug-in connector. This construction facilitates manufacture, standardization, and maintenance and allows a very flexible combination of control functions to be provided to suit the immediate needs of the user.

For motors of higher horsepower ratings, polyphase power circuits are employed so as to distribute the motor load among more tubes and all three phases of the a-c system. The grid phase control becomes more of a problem during inversion but this is corrected by negative d-c grid bias voltages added to the alternating voltages from the polyphase bridge phase-shifting circuits.

Future Trends

Since thyratron tubes are already commutating armature current from one tube to another under conditions of both rectification and inversion, it is only logical to expect that future electronic drives will combine in these same thyratrons the commutating functions inherent in the d-c motor itself, so that an a-c synchronous-type, commutatorless motor, supplied from a-c through thyratron tubes, will have all the variable-speed characteristics of a d-c machine thyratron motor.

Meanwhile, developments are progressing towards the use of ignitron-type tubes to provide armature excitation for motors of higher horsepower ratings than can now be supplied from the available hot-cathode type thyratron tubes.

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(See Opposite Page)

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